No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,

Petitioners.

APPENDIX OF ATTACHMENTS IN SUPPORT OF PETITION FOR WRIT OF MANDAMUS

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www.tampabay.com /news/environment/2021/04/17/failure-at-piney-point-a-disaster-foretold/

Failure at Piney Point: Florida let environmental risk fester despite warnings

Bethany Barnes, Christopher O'Donnell, Zachary T. Sampson ⁝ 21-26 minutes ⁝ 4/17/2021

PALMETTO — As early as 2008, the U.S. Army Corps of Engineers was predicting possible disaster at the old Piney Point phosphate plant in Manatee County if a plan to use the site for dredging went forward.

The “worst case scenario,” the Army Corps cautioned, would be a tear in the plastic liner that engineers were counting on to hold back water perched atop dangerous waste material. Another worry the Army Corps raised: What if the private company in charge went bankrupt?

Army Corps officials warned the Manatee County Port Authority, which was counting on the increase in business. They warned the Florida Department of Environmental Protection, which stood to show it could transform a costly mess into an asset. And those warnings reached HRK Holdings, the private company that bought the site and planned to make millions from storing dredge material.

All of them pushed back. And then the worst happened. The liner failed almost immediately after dredging began. Now, 10 years later, it has happened again.

This month, a leak at Piney Point drove Manatee County to the nervous edge of catastrophe. Fearing a flood would rip through the surrounding community, authorities ordered the evacuation of more than 300 homes. More than 200 million gallons of wastewater have been pumped into Tampa Bay, the environmental impact of which is still unknown.

Under a spotlight in the aftermath, the Florida Department of Environmental Protection is pledging to hold HRK accountable. But the agency isn’t a minor actor in the story of what went wrong at Piney Point. Florida’s environmental regulator agreed to a plan that put a group of New York financiers in charge of what was arguably the state’s biggest ecological risk. The agency questioned warnings from engineers who sounded the alarm that a major leak could happen. And the state knew HRK was behind on its goal to get rid of the polluted water.

Even the agency’s top official is bewildered by how Piney Point was ever allowed to become a dump site run by an inexperienced private company.

“The more I learn, the less I understand,” said Department of Environmental Protection Secretary Noah Valenstein during a news conference with the governor this week.

Florida Department of Environmental Protection Secretary Noah Valenstein speaks to a state House committee about Piney Point on April 7. [The Florida Channel]

The state had money to close Piney Point for good before but chose to leave the site open for future business interests, the secretary told lawmakers April 7. That has left “the property still there as a risk,” Valenstein said.

Since the latest leak was first noticed, a familiar pattern has emerged. Everyone involved is pointing fingers elsewhere. But records show officials at all levels — the state, the company, the county — had a hand in what Piney Point became. The county backed an idea to put more waste at Piney Point, the company looked at an environmental risk and saw a chance to profit, and the state stood by as a looming environmental danger festered on its watch.

An overhead view of water around Port Manatee, near Piney Point. [LUIS SANTANA | Times]

Dredging Port Manatee

Port Manatee was looking to dredge a new berth, becoming an attractive destination for huge freighter ships sailing through the Panama Canal. It needed a place to put all the muck.

In Piney Point, port officials saw opportunity.

The Port Authority, made up of Manatee County commissioners, approached the Florida Department of Environmental Protection about the idea, the *Bradenton Herald* reported in 2005.

The state was on board, seeing a chance to make something useful out of an industrial site with a troubled history. It had spent years trying to drain acidic wastewater from Piney Point's radioactive phosphogypsum stacks, replacing the ponds with plastic-lined reservoirs.

Port records show that department officials and a consultant engineer, Ardaman & Associates, met with the Port Authority's governing board in October 2005. They touted the strength and longevity of the liner, saying it was a material that would "survive the elements well past our lifetimes."

Former commissioner and Port Authority board member Joe McClash said board members were given samples to touch.

"There was a high degree of confidence because it was the same material used for landfills," said McClash.

A private company saw opportunity, too. Despite the contamination, industrial land close to a seaport made Piney Point an enticing real estate investment for HRK, which purchased the roughly 700-acre site in 2006. In a dredging agreement with the port, HRK could quickly make millions of dollars and fill in some of the old gypsum stacks.

But in 2008, the Army Corps of Engineers released a 72-page study calling the idea a risk.

“I got through 5 pages of this utter nonsense from the (Army Corps of Engineers) before my blood pressure hit the red zone,” HRK representative Art Roth wrote after reading the report, according to an email filed in court records. “Obviously, facts, experience and expert opinion don’t matter.”

Raw materials are offloaded from the Ivy Unicorn cargo ship at Port Manatee earlier this month. [DOUGLAS R. CLIFFORD | Times]

HRK executives didn’t have first-hand experience in dealing with the complex geology of a gypsum stack, but they did have something else working in their favor: the Florida Department of Environmental Protection and its engineering consultants at Ardaman.

HRK, with the agency’s approval, tapped Ardaman to rebut the Army Corps. The engineer had a long history with Piney Point, having worked with the state on closure efforts for years.

Ardaman tamped down fears in a report, professing confidence and repeatedly calling a leak “unlikely.”

The Army Corps continued to oppose the project.

An Army Corps official wrote to the executive director of the port in 2009 saying that even if the risk of failure was low, “the consequences could be great.” He noted HRK could go

bankrupt, like prior owners who operated the phosphate plant on the site. That would put the state in a jam. More to the point, the risks were unnecessary because a cheaper, safer option existed to dump the dredge material miles offshore into the Gulf of Mexico.

The Florida Department of Environmental Protection threw its weight behind Piney Point, too. Then-Secretary Michael Sole wrote to an Army Corps leader that the state had “previously identified several benefits to the local environment and community” from disposing of dredge spoils there.

An official under him at the agency noted the department had spent more than $100 million cleaning Piney Point and continued to hope the new reservoirs would be useful for a project such as dredging. The agency gave assurances that the Army Corps would be shielded from litigation if something went wrong.

The Army Corps was still worried, records show, almost right up until the 2011 dredge operation began. A high-ranking Army Corps official in Washington, D.C., wrote the port saying the plan was needlessly risky.

The Army Corps would not agree to an interview for this story. Ultimately, it let the dredging go forward.

Disposal began that April. In May, there were signs of a leak, which an expert eventually traced to a tear in the liner. The Department of Environmental Protection, fearing the leak would disrupt the gypsum stacks, issued an emergency order letting crews send about 170 million gallons of potentially contaminated water toward Tampa Bay.

HRK has since sued Ardaman saying the company relied on the engineering firm’s assurances and expertise that the plastic liner system would hold. That litigation has been tied up in court for eight years. Ardaman’s attorney did not answer emails for comment. The company did not reply to a request for comment submitted through a contact form.

Now, with another breach to answer for, HRK is again arguing it was misled by Ardaman.

Effluent flowed from a pipe into a drainage ditch at Port Manatee South Gate across from the old Piney Point phosphate plant site earlier this month.
[DOUGLAS R. CLIFFORD | Times]

A recent warning

The liner that kept water in the large reservoir at Piney Point, stopping it from leaking, is about 0.08 inches thick. That's equal to 76 Hefty strong trash bags.

After the 2011 leak, and subsequent fixes, officials continued to trust the plastic liner. But fears did not subside, and the state required HRK to make routine inspections.

As recently as March 2020, an independent engineer brought on to evaluate Piney Point warned of a looming disaster.

The potential for "catastrophic damage to the public and the environment is considered unacceptable," two engineers for the firm, Wood, declared in a letter to HRK and the Department of Environmental Protection.

The engineers described liner tears above the water level, the "unknown and likely compromised condition" below the surface and possible lingering trouble from the 2011 incident. They suggested the reservoir "should immediately be drained" and kept stable until the gypsum stack system could be closed.

State regulators were taken aback. The letter contained "several factually incorrect statements," according to the state.

In response, John Coates, the manager for the Department of Environmental Protection's mining and mitigation program, questioned what proof Wood could have for some of the letter's assertions. The engineers had only looked at part of the liner that was above

water, which would be more worn from the sun, he wrote. Coates had been involved with oversight at Piney Point for years.

If the Wood engineers had qualms about lingering issues from the 2011 leak, Coates wrote, they could have spoken up earlier, in previous years working at the site. The agency did not make Coates available for an interview.

Dee Ann Miller, a spokesperson for the Department of Environmental Protection, said the state did not receive a reply to Coates' letter. But it did receive an annual inspection report dated June 2020 in which the same engineering firm described the phosphogypsum stack system as "generally in good condition based on Wood's visual inspection."

A Wood representative declined to comment.

An overhead image shows work on the Piney Point site at the corner of a wastewater pond. [LUIS SANTANA | Times]

Throughout the rest of 2020, records show, HRK staffers continued to document small cracks or potential flaws above the water line.

"HRK routinely inspects, notifies FDEP, and corrects synthetic liner flaws identified above the water line of the water storage compartments," the company said in a statement this week. Valenstein, the department secretary, has said "that's the ongoing process with a liner system."

About a year after Wood's warning, residents around the old plant property would flee their homes on the recent Easter weekend, as authorities warned that a leak from a liner tear could cause the collapse of Piney Point.

Then, the blame began.

Signs of trouble

HRK Holdings has two main responsibilities at Piney Point, according to a presentation Coates, of the Department of Environmental Protection, gave to Manatee commissioners in January 2019.

• Clean up and manage the site.

• Provide financial assurance that the property will be cared for decades into the future.

It was the department's job to make sure they did that, Coates said. "They have to be held accountable, and they are being accountable."

But HRK has struggled to meet its obligations, records show.

Engineers working at the site repeatedly documented how the company was not disposing of polluted water fast enough to meet a Feb. 15, 2019, deadline in an agreement with the state. HRK did not have the technology or equipment needed to finish the job on time, the independent engineers said.

The company said this week it "has continuously and diligently relayed concern to all who would listen of the impending problems and risks" at Piney Point and "has proposed numerous solutions to" state and local government without getting approval or funding. HRK pushed for a deep well to inject wastewater underground, among other solutions.

A sign regulates passage into an inlet at a coastal mangrove estuary off Port Manatee near Piney Point. [DOUGLAS R. CLIFFORD | Times]

Rain has continued to fill the site. Jeff Barath, HRK's manager at Piney Point, recently told elected officials in Manatee that without help, wastewater could soon overwhelm the ponds.

To assure the state that Piney Point will be managed into the future, the company has had to keep money in a trust. HRK says it has to get state approval to pay for at least some repairs on the property.

The fund gives the Department of Environmental Protection money in case HRK goes out of business and the state has to step in to manage Piney Point again. That's what happened when the plant's last private owner, Mulberry Corp., failed two decades ago. Coates said the acidic wastewater ponds would have overflowed without state intervention.

But, Coates told commissioners in early 2019, the money HRK held with the state was not enough to take care of all the waste at Piney Point in the event the company went out of business.

As of March 31, about the time this leak was reported, a financial report provided by the Department of Environmental Protection showed that HRK had less than $2.5 million in a fund overseen by the Florida Department of Financial Services.

Lawmakers are now talking about spending as much as $200 million to close the place for good.

The money men

HRK Holdings was an unusual choice to take over an abandoned phosphate plant.

Valenstein, the state's top environmental official, has said other sites like Piney Point are run by active mining companies.

HRK was created by a group of three Wall Street financiers: William "Mickey" F. Harley III, Scott Rosenzweig and Gary Kania. The firm, set up as a limited liability corporation, took its name from their initials with Harley and Rosenzweig each owning 40 percent and Kania 20.

Kania later left HRK and Rosenzweig died in 2012.

Harley had a reputation for buying companies in financial trouble. A 2004 profile in Forbes described him as a "vulture" who learned about distressed firms while working at investment bank Allen & Co., before he moved on to manage Mellon HBV's $1.2 billion hedge fund. It catered to affluent investors who could afford the $1 million minimum investment.

Harley declined to comment for this story.

A graduate of the Yale School of Management, Harley at one time owned a handful of Hooters franchises and held $6 million in stock in Frederick's of Hollywood, the lingerie retailer, where he also served on the board of directors. He sat on the board of a

Canadian-based energy firm that mined for uranium in Namibia. Later, he invested in a pecan farm.

The *Bradenton Herald* reported that the investors learned of Piney Point from Roth, a fertilizer consultant, who was then hired by HRK.

But records show that in 2001 Kania was following the bankruptcy of Mulberry Corp. closely. He was a vice president at a New York-based bank and was listed as its contact in a claim made in bankruptcy filings that Mulberry owed the bank $36.6 million.

Piney Point opened in 1966 as a Borden Chemical Co. plant. [STAFF | Times files]

Tampa attorney Herb Donica was hired by Mulberry Corp bankruptcy trustee John Brook after Piney Point closed. He visited the site off U.S. Hwy. 41 so often, paint began to peel from his silver Mercedes, the result of acid from an abandoned pond on the site drifting through the air, he said.

The job of the trustee was to get the best deal for Mulberry's many creditors, but it wasn't like a normal bankruptcy since the site was under the control of the Florida Department of Environmental Protection, Donica told the *Tampa Bay Times.*

Manatee commissioners declined the chance to buy the site for $4 million, saying it was too polluted even for that bargain price.

Other companies were interested in acquiring Piney Point, but Kania's familiarity with the site gave HRK an advantage, Donica said this week.

Around the time of the sale, he told the *Sarasota Herald-Tribune*: "They satisfied us that they knew what they were getting into. We were never going to turn it loose to someone who wasn't aware of the managing and monitoring that is required."

Brook, the trustee, said last week that the Department of Environmental Protection vetted HRK and approved the sale.

HRK financed the $4.3 million purchase through a $10 million loan secured by a mortgage on Piney Point from AmSouth Bank, which later merged with Regions Bank. It was also required to pay $3.8 million to the department toward the ongoing cleanup of the site.

Court records show that the company struggled even as it borrowed more money from Regions. By 2008, liens were being filed against the Piney Point property, and HRK was sued for $1.7 million because it failed to pay a construction company to demolish old phosphate factory equipment.

By 2010, Regions agreed to consolidate the firm's debt into a single promissory note of $17.5 million.

Storage containers are seen in March at the old Piney Point phosphate plant site. [DOUGLAS R. CLIFFORD]

There was some money coming in. The firm leased land to a salt company that wanted storage. A warehouse for keeping fertilizer was built and the start of the pumping of dredging material from Port Manatee's Berth 12 project promised more revenue. Port records show HRK was paid $3 million through 2011.

The company's finances nosedived after the first leak.

Barely more than a year later, it filed for Chapter 11 bankruptcy protection in Tampa federal court. Claims from creditors reached $33 million. That included a $12 million lien from Port Manatee, which had been sued by the dredging company claiming that the delay caused by the leak had cost it $4.7 million.

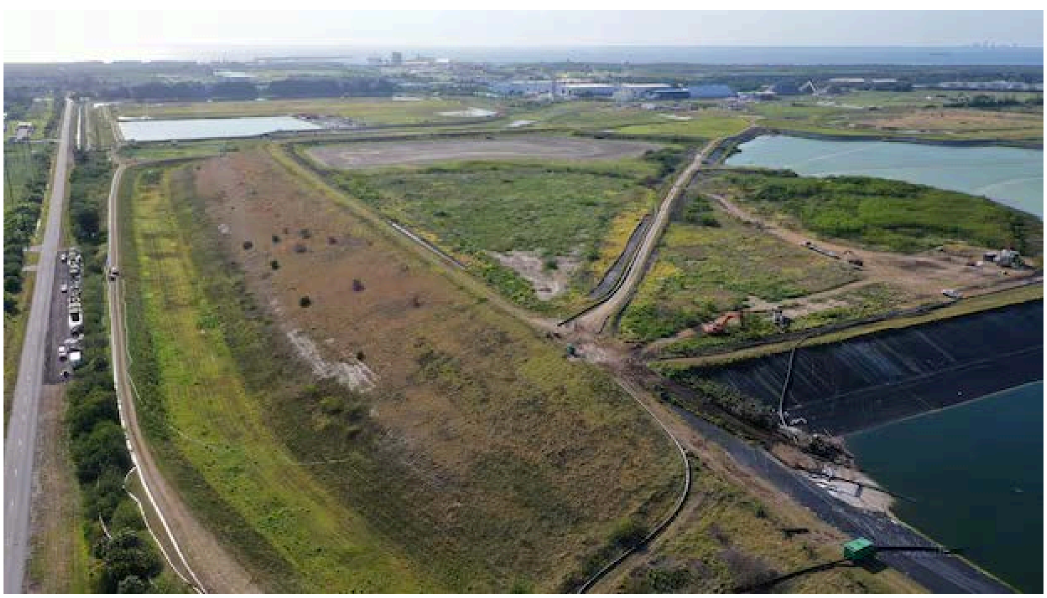
Harley, HRK's principal owner, was also hit with a lawsuit filed a few months later by the Claude Worthington Benedum Foundation. The wealthy Pittsburgh nonprofit accused Harley of misusing its $2 million investment to make payments to companies he owned, including HRK, through his hedge fund.

Soon after, regular reports showed the value of the nonprofit's investment was plummeting. By April 2008, its $2 million investment had dwindled to $306,000, the lawsuit claims.

Around June 2009, Harley closed the hedge fund's offices, the lawsuit states, and started operating the fund out of a Hooters basement.

The lawsuit alleged that he transferred the remaining investment funds into a company he owned called the Arsenal Group. Arsenal sent hundreds of thousands of dollars to HRK during its bankruptcy, court records show. The lawsuit was closed after the two sides agreed to a settlement. The terms were not disclosed.

HRK emerged from bankruptcy in 2017, although it remained millions of dollars in debt to Regions Bank.



An aerial perspective on HRK Holdings' Piney Point property looking toward Port Manatee. [LUIS SANTANA | Times]

What now?

The state is vowing this will be Piney Point's "last chapter."

How that will happen is unclear. Gov. Ron DeSantis has directed the Department of Environmental Protection's scientists and engineers to draw up a plan. Valenstein, the department's secretary, said closure will mean draining and filling the ponds to make sure water can no longer be stored at Piney Point.

The governor has redirected about $15 million toward treating water at the site. State lawmakers say they could greenlight up to $200 million for closure.

The leaking reservoir today, according to state regulators, contains a mix of old seawater from the dredging, rainwater and polluted water related to the fertilizer industry.

Florida Gov. Ron DeSantis speaks during a news conference at Piney Point. Department of Environmental Protection Secretary Noah Valenstein stands over the governor's shoulder. [RYAN CALLIHAN | AP]

Manatee County administrator Scott Hopes says what happened isn't the county's fault and points out that Piney Point was the responsibility of a private landowner that was overseen by the state.

"Certainly, the county did not have the resources to do what's being done right now," he said.

Valenstein told lawmakers this month that he is interested in ordering a report detailing his agency's actions at Piney Point.

Already, another business is circling the property.

In September, Regions Bank assigned HRK's outstanding debt to Fortress 2020 Landco. Soon after, Fortress sued HRK seeking to foreclose on several debts and lines of credit that HRK has failed to repay. The loans total $25 million, according to the lawsuit.

It's unclear what investor or company is behind Fortress. The company was registered in August in Delaware, a state that draws hundreds of thousands of business registrations because of laws that keep executives' names confidential.

Records filed with Florida's Division of Corporations, also in August, list a business address in Fort Worth, Texas. Orla Drilling, which works with oil and mining companies, is listed as operating from that site. HRK has filed motions seeking to have the Fortress lawsuit dismissed.

This new legal battle could complicate the governor's plan for the state to clean up the site permanently and hold HRK accountable.

Glenn Compton, who is chairperson of the local environmental group ManaSota-88, doubts the state will be able to get much money from HRK. He has long criticized what he sees as mismanagement and poor regulation of Piney Point. He considers it a "historic mistake" that will be difficult to bring to a close, the culmination of decades of poor choices and the lasting fallout of Florida's fertilizer industry.

"What we've learned is there's no such thing as a future beneficial use of a phosphogypsum stack. These are wastelands, and they'll be wastelands for generations to come," Compton said. "The price is being paid by the taxpayers and the environment."

An overhead drone image shows water off Manatee County near Piney Point.
[LUIS SANTANA | Times]

STATE OF FLORIDA

OFFICE OF THE GOVERNOR
EXECUTIVE ORDER NUMBER 21-82

(Emergency Management-Eastport Terminal Facility)

WHEREAS, on March 25, 2021, HRK Holdings L.L.C., who is the responsible entity for the operation of the phosphogypsum stacks at Eastport Terminal facility, reported increased flow and specific conductivity measurements indicating the presence of a leak from the Site's NGS-S lined compartment; and

WHEREAS, the Site's NGS-S Structure 1 lined compartment contains 480 million gallons of a mixture of seawater and remnant process water from the historical fertilizer manufacturing operations at the site; and

WHEREAS, as of March 28, 2021, the drain flow rates and conductivity measurements have continued to increase by an unidentified source, causing potential risks and system instability; and

WHEREAS, the Department of Environmental Protection has determined that the site is an imminent hazard pursuant to section 403.4154, Florida Statutes, which creates an immediate and substantial danger to human health, safety, welfare and the environment; and

WHEREAS, the Department of Environmental Protection has determined the potential risks caused by the conductivity measurements at Structure 1 create an imminent threat of potential loss of containment and the release of large amounts of seawater, mixed process water, and embankment materials if immediate action is not taken; and

WHEREAS, due to this danger it is vital that local disaster response agencies prepare for the evacuation of persons from communities at risk of flooding due to their close proximity to

the facility for the safety of the residents and law enforcement will need to take action as needed to divert traffic and clear waterways; and

WHEREAS, other emergency measures may be needed to protect the lives and property of the people in the threatened communities, and the general welfare of the State of Florida; and

WHEREAS, immediate emergency actions shall be taken to abate or substantially reduce the imminent hazard and stabilize all of the systems dikes, berms, and ditches to prevent a containment failure; and

WHEREAS, as Governor, I am responsible for meeting the dangers presented to this state and its people by this emergency.

NOW, THEREFORE, I, RON DESANTIS, as Governor of Florida, by virtue of the authority vested in me by Article IV, Section 1(a) of the Florida Constitution and by the Florida Emergency Management Act, as amended, and all other applicable laws, promulgate the following Executive Order, to take immediate effect:

Section 1. Because of the foregoing conditions, I find that the prospect of one or more systems failures at the Eastport Terminal Facility threatens the State of Florida with a disaster and environmental emergency. I therefore declare that a state of emergency exists in Hillsborough, Manatee, and Pinellas Counties due to the proximity of these counties to the facility. I further find that in the event a dangerous release is imminent, central authority over the evacuation of these counties will be needed to coordinate the evacuation, because the evacuation will exceed the capabilities of the local governments in these communities.

Section 2. I designate the Director of the Division of Emergency Management as the State Coordinating Officer for the duration of this emergency. In exercising the powers delegated by this Executive Order, the State Coordinating Officer shall confer with the Governor to the fullest extent practicable. In accordance with sections 252.36(1)(a) and 252.36(5), Florida

Statutes, I delegate to the State Coordinating Officer the following powers, which he shall exercise subject to the limitations of section 252.33, Florida Statutes, as needed to meet this emergency:

A. The authority to activate the Comprehensive Emergency Management Plan ("CEMP");

B. The authority to invoke and administer the Statewide Mutual Aid Agreement ("SMAA"), and the further authority to coordinate the allocation of resources under that Agreement so as best to meet this emergency;

C. The authority to seek direct assistance from any and all agencies of the United States Government as may be needed to meet the emergency;

D. The authority to distribute any and all supplies stockpiled to meet the emergency;

E. The authority to suspend existing statutes, rules, ordinances, and orders for the duration of this emergency to the extent that literal compliance with such statutes, rules, ordinances, and orders may be inconsistent with the timely performance of disaster response functions;

F. The authority to suspend the effect of any statute or rule governing the conduct of state business, and the further authority to suspend the effect of any order or rule of any governmental entity, to include, without limiting the generality of the foregoing, any and all statutes and rules which affect budgeting, printing, purchasing, leasing, procurement, and the conditions of employment and the compensation of employees; provided, however, that the State Coordinating Officer shall have authority to suspend the effect of any statute, rule or order only to the extent necessary to ensure the timely performance of vital emergency response functions;

G. The authority to relieve any and all state agencies responsible for processing applications or petitions for any order, rule, or other final action subject to the Administrative

Procedure Act, as amended, from the deadlines specified in that Act and in other applicable laws for the duration of this emergency, if the State Coordinating Officer finds that such deadlines cannot be met because of this emergency;

H. The authority to direct all state, regional, and local governmental agencies, including law enforcement agencies, to identify personnel needed from those agencies to assist in meeting the needs created by this emergency, and to place all such personnel under the direct command of the State Coordinating Officer to meet this emergency;

I. The authority to seize and utilize any and all real or personal property as needed to meet this emergency, subject always to the duty of the State to compensate the owner;

J. The authority to order evacuation, and the authority to direct the sequence of evacuation in which such evacuations shall be carried out, and the further authority to regulate the movement of persons and traffic to, from, or within the affected counties to the extent needed to cope with this emergency;

K. The authority to regulate the return of the evacuees to their home communities;

L. The authority to designate such Deputy State Coordinating Officers as the State Coordinating Officer may deem necessary to cope with the emergency; and

M. The authority to enter such orders as may be needed to implement any or all of the foregoing powers.

Section 3. I direct each of the counties named in Section 1 of this Executive Order to activate its County Emergency Management Plan to ensure an immediate state of operational readiness, and I further direct the remaining counties in the State of Florida, at the discretion of the State Coordinating Officer, to prepare to activate all shelters to accommodate the evacuees.

Section 4. I direct all state, regional, and local agencies to place any and all available resources under the direction of the State Coordinating Officer as needed to meet this

emergency. The Department of Law Enforcement shall have the operational authority to coordinate and direct law enforcement resources and other resources of any and all local, regional, and state governmental agencies that the Department may designate to take the precautions needed to protect the State of Florida from terrorist acts. I place all law enforcement resources under the operational authority of the Department of Law Enforcement while this Executive Order remains in effect. In exercising the powers delegated by this Executive Order, the State Coordinating Officer shall coordinate the response to this event by law enforcement resources of the State in consultation with the Department of Law Enforcement.

Section 5. I designate all state, regional, and local governmental facilities including, without limiting the generality of the foregoing, all public elementary and secondary schools, all Community Colleges, and all State Universities, at the discretion of the State Coordinating Officer for use as shelters to ensure the proper reception and care of all evacuees.

Section 6. In accordance with sections 252.36(5)(a) and 252.46(2), Florida Statutes, all statutes, rules, and orders are hereby suspended for the duration of this emergency to the extent that literal compliance with such statutes, rules, and orders may be inconsistent with the timely performance of emergency response functions. I also find that the special duties and responsibilities resting upon some state, regional and local agencies and other governmental bodies in responding to the emergency may require them to deviate from the statutes and rules they administer. Without limiting the generality of the foregoing, I order the following:

A. Pursuant to section 252.36(1)(a), Florida Statutes, the Executive Office of the Governor may suspend all statutes and rules affecting budgeting to the extent necessary to provide budget authority for state agencies to cope with this emergency.

B. To the extent that the demands placed upon the funds appropriated to the agencies of the State of Florida and to local agencies are unreasonably great and the funds currently

available may be inadequate to pay the costs of coping with this emergency, I direct that sufficient funds be made available, as needed, by transferring and expending moneys appropriated for other purposes, moneys from unappropriated surplus funds, or from the Budget Stabilization Fund.

C. I authorize the Department of Transportation to waive the size and weight restrictions for divisible loads on any vehicles transporting emergency equipment, services and supplies, allowing the establishment of alternate size and weight restrictions for all such vehicles for the duration of the emergency, to the extent such waivers are needed to meet this emergency. Commercial vehicles allowed to operate outside the normal restrictions for such vehicles under the authority of this Executive Order shall be issued permits by the Department of Transportation, and such vehicles shall be subject to such special conditions as the Department may endorse on any such permits. Nothing in this Executive Order shall be construed to allow any vehicle to exceed weight limits posted for bridges and like structures, nor shall anything in this Executive Order be construed to relieve any vehicle or the carrier, owner, or driver of any vehicle from compliance with any restrictions other than those specified in this Executive Order, or from any statute, rule, order or other legal requirement not specifically waived herein.

D. At the request of the director of a county emergency management agency, I direct the Department of Health take over the operation of all shelters in that county that are intended for use by those evacuees with special personal, medical or psychological needs, and to station licensed medical professional and paraprofessional personnel at those shelters as needed to provide appropriate reception and care for such evacuees.

E. I give the Department of Environmental Protection the authority to take any actions necessary to abate the imminent hazard and to minimize adverse environmental impacts,

including those specified in section 403.4154, Florida Statutes. Additionally, the Department of Environmental Protection has the authority to close state parks and other state recreational facilities under its jurisdiction in those counties of the State affected by the emergency, as needed to meet the emergency.

F. I give all agencies of the State, including the collegial bodies within those agencies, the authority to suspend the effect of any statute, rule, ordinance, or order of any state, regional, or local government entity, to the extent needed to procure any and all necessary supplies, commodities, services, temporary premises, and other resources, to include, without limiting the generality of the foregoing, any and all statutes, rules, ordinances, or orders which affect budgeting, leasing, printing, purchasing, travel and the condition of employment and the compensation of employees, but any statute, rule, ordinance, or order shall be suspended only to the extent necessary to ensure the timely performance of disaster response functions as prescribed in the State Comprehensive Emergency Plan (CEMP), or as directed by the State Coordinating Officer; however, any waiver of statutes, rules, or ordinances governing travel shall expire in fourteen (14) days from the date of this Executive Order unless extended (in increments of no more than fourteen days) by the agency.

G. I give all agencies of the State the authority to allow overnight stays by employees of the State who travel a distance of less than fifty (50) miles for the performance of official duties in connection with the emergency, and the authority to allow employees of the State reimbursement for the cost of meals during Class C travel incurred in connection with this emergency.

H. I give all agencies of the State responsible for the use of state buildings and facilities the authority to close such buildings and facilities in those portions of the State affected by this emergency, to the extent to meet this emergency; and

I. I give all agencies of the State, including the collegial bodies within those agencies, the authority to abrogate the time requirements, notice requirements, and deadlines for final action on applications for permits, licenses, rates, and other approvals under any statutes or rules under which such application are deemed to be approved unless disapproved in writing by specified deadlines, and all such time requirements that have not yet expired as of the date of this Executive Order are suspended and tolled to the extent needed to meet this emergency.

Section 7. Pursuant to section 376.121, Florida Statutes, to the extent permitted by law, state agencies responding to this emergency shall seek reimbursement from the responsible party.

Section 8. Medical professionals and workers, social workers, and counselors with good and valid professional licenses issued by States other than the State of Florida may render such services in the State of Florida during this emergency for persons affected by this emergency with the condition that such services be rendered to such persons free of charge, and with the further condition that such services be rendered under the auspices of the American Red Cross or the Department of Health.

Section 9. All state agencies that enter emergency final orders or take other final actions based on the existence of this emergency shall advise the State Coordinating Officer in writing of the action taken as soon as practicable, but in no event later than the expiration of sixty (60) days from the date of this Executive Order.

<u>Section 10.</u> All actions taken by the Director of the Division of Emergency Management with respect to this emergency before the issuance of this Executive Order are hereby ratified. This Executive Order shall expire sixty (60) days from this date unless extended.

IN TESTIMONY WHEREOF, I have hereunto set my hand and caused the Great Seal of the State of Florida to be affixed, at Tallahassee, this 3rd day of April, 2021.

RON DESANTIS, GOVERNOR

ATTEST:

SECRETARY OF STATE

FILED
2021 APR -3 PM 4:13
DEPARTMENT OF STATE
TALLAHASSEE, FL

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Initial estuarine response to inorganic nutrient inputs from a legacy mining facility adjacent to Tampa Bay, Florida

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A B S T R A C T

Legacy mining facilities pose significant risks to aquatic resources. From March 30th to April 9th, 2021, 814 million liters of phosphate mining wastewater and marine dredge water from the Piney Point facility were released into lower Tampa Bay (Florida, USA). This resulted in an estimated addition of 186 metric tons of total nitrogen, exceeding typical annual external nitrogen load estimates to lower Tampa Bay in a matter of days. An initial phytoplankton bloom (non-harmful diatoms) was first observed in April. Filamentous cyanobacteria blooms (*Dapis* spp.) peaked in June, followed by a bloom of the red tide organism *Karenia brevis*. Reported fish kills tracked *K. brevis* concentrations, prompting cleanup of over 1600 metric tons of dead fish. Seagrasses had minimal changes over the study period. By comparing these results to baseline environmental monitoring data, we demonstrate adverse water quality changes in response to abnormally high and rapidly delivered nitrogen loads.

1. Introduction

Wastewater byproducts from mining are a global threat to the quality of surface and groundwater resources (Hudson-Edwards et al., 2011; Tayibi et al., 2009). The production of phosphate fertilizer generates large amounts of phosphogypsum waste ($CaSO_4 \cdot H_2O$) that is typically stored on-site in large earthen stacks (gypstacks) capable of holding hundreds of millions of liters of process water. Water quality in gypstacks can vary depending on processing method used at the mining facility, background geological characteristics of the region, and on-site practices for managing stormwater or other activities that can introduce additional materials to the holding ponds (Henderson, 2004; Pérez-López et al., 2010). In addition to elevated phosphorus concentrations, other nutrients, contaminants, and radionuclides may be present at values much higher than natural surface waters (Beck et al., 2018a; Burnett and Elzerman, 2001). Many of these gypstacks no longer support active mining and aging infrastructure combined with climate change and seasonal stressors (e.g., heavy precipitation events) have reduced the capacity of these facilities to maintain water on site. Numerous studies have documented the environmental and human health risks

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associated with these stacks (Beck et al., 2018a; El Zrelli et al., 2015; Pérez-López et al., 2016; Sanders et al., 2013; Tayibi et al., 2009).

The geology of central Florida is rich in phosphates that have supported a multi-billion dollar mining industry for fertilizer to support agricultural production (Henderson, 2004). By 2001, an estimated 36 million metric tons of phosphogypsum were created each year in northern and central Florida (Burnett and Elzerman, 2001). Effective management and final closure of these facilities are imperative to reduce threats to prior ecosystem recovery efforts and investments. The Piney Point facility located in Palmetto, Florida is a large, remnant gypstack with three holding ponds located 3 km from the shore of Tampa Bay and near two Florida Aquatic Preserves [see supplement for a history of the facility; Henderson, 2004]. Holding capacity of the ponds has decreased over time from seasonal rain events, tropical storms, and storage of dredging material from nearby Port Manatee. Releases from the stacks occurred in the early 2000s and in 2011 to nearby Bishop Harbor connected to Tampa Bay. Those releases resulted in spatially-restricted, ecosystem responses including localized harmful algal blooms and increased macroalgal abundance (Garrett et al., 2011; Switzer et al., 2011).

In March 2021, leakages were detected from a tear in the plastic liner of the southern holding pond (NGS-S) at Piney Point. At that time, approximately 1.8 billion liters of mixed legacy phosphate mining wastewater and seawater from port dredging operations were being held in the failing gypstack. Piney Point historically produced Diammonium Phosphate ($(NH_4)_2HPO_4$) and the remnant stackwater has very high concentrations of total nitrogen (TN), in addition to total phosphorus (TP). Water quality parameters of NGS-S measured in 2019 showed TP (160 mg/L) and TN (230 mg/L) were approximately three orders of magnitude higher than typical concentrations in Tampa Bay. From March 30th to April 9th, approximately 814 million liters (215 million gallons) of stack water were released to lower Tampa Bay following an emergency order authorized by the Florida Department of Environmental Protection (FDEP). Over this ten day period, an estimated 186 metric tons (205 tons) of nitrogen were delivered to the bay, exceeding contemporary annual estimates of external nutrient loads to lower Tampa Bay in a matter of days (Janicki Environmental, Inc., 2017).

This paper provides an initial assessment of environmental conditions in Tampa Bay over the six month period after the release of legacy phosphate mining wastewater from the Piney Point facility in 2021. The goal is to describe the results of monitoring data of surface waters collected in response to the event to assess relative deviation of current conditions from long-term, seasonal records of water quality, phytoplankton, and seagrass/macroalgae datasets available for the region. Numerous studies, as well as the successful nutrient management paradigm, have demonstrated nitrogen-limitation in Tampa Bay and the system is generally considered phosphorus enriched (Greening et al., 2014; Greening and Janicki, 2006; Wang et al., 1999). As such, we focus on nitrogen in our analyses as the identified limiting nutrient for Tampa Bay and its potential to create water quality conditions unfavorable for seagrass growth due to enhanced algal production. Our analysis evaluated datasets that are descriptive of the vulnerability of seagrasses to nutrient pollution though cascading negative effects of nitrogen, phytoplankton growth and persistence, and water clarity on seagrass growth and survival (Beck et al., 2018b; Dixon and Leverone, 1995; Greening and Janicki, 2006; Kenworthy and Fonseca, 1996). A timeline of events is provided, which is supported by the quantitative results from 2021 routine and response-based monitoring of conditions in and around Port Manatee, FL – the focal point of emergency releases from the Piney Point facility. The results from this paper provide an unprecedented chronology of short-term estuarine response to acute nutrient loadings from legacy mining facilities, where context would not have been possible without the long-term monitoring datasets available for the region.

2. Methods

2.1. Simulation modeling

Monitoring of the natural resources of Tampa Bay in response to the release from Piney Point began in April 2021 and continued for six months through September. These data were collected through a coordinated effort under the guidance of a plume simulation by a numerical circulation model run by the Ocean Circulation Lab at the University of South Florida (USF), College of Marine Science. The plume evolution from Piney Point was simulated using the Tampa Bay Coastal Ocean Model (TBCOM) nowcast/forecast system (Chen et al., 2018, 2019), with an embedded tracer module that included realistic release rates. Normalized tracer distributions were automatically updated each day, providing 1-day hindcasts and 3.5-day forecasts throughout the period of discharge and subsequent Tampa Bay distribution. The modeled plume evolution web product (http://ocgweb.marine.usf.edu/~liu/Tracer/) served as the principal guidance for coordinating the data collection during the event. Preliminary model results for Piney Point are reported in Liu et al. (2021) and previous model veracity testing was described in Chen et al. (2018) and Chen et al. (2019) (and references therein).

2.2. Monitoring response to the emergency release

Monitoring agencies and local partners that collected data using standardized protocols included FDEP, Environmental Protection Commission (EPC) of Hillsborough County, Parks and Natural Resources Department of Manatee County, Pinellas County Division of Environmental Management, Fish and Wildlife Research Institute (FWRI) of the Florida Fish and Wildlife Conservation Commission (FWC), City of St. Petersburg, Tampa Bay Estuary Program (TBEP), Sarasota Bay Estuary Program, Environmental Science Associates, University of South Florida, University of Florida, and New College of Florida. Monitoring efforts focused on a suite of parameters expected to respond to increased nutrient loads into the bay, including water quality sampling, phytoplankton identification, and seagrass and macroalgae transect surveys (Fig. 1).

Water quality parameters included discrete, laboratory-processed and in situ samples for TN (mg/L), total ammonia nitrogen (NH_3 + NH_4^+, mg/L, hereafter referred to as ammonia), nitrate/nitrite (NO_3^- + NO_2^-, mg/L), TP (mg/L), orthophosphate (PO_4^{3-}, mg/L), chlorophyll-a (chl-a, μg/L), pH, salinity (ppt), temperature (°C), and dissolved oxygen saturation (%). Most samples were surface collections by boat, with sample frequency approximately biweekly for locations around Piney Point, although effort varied by monitoring group and was more consistent during the first three months after the release. Established laboratory and field sample protocols for all survey methods were based on an Interagency Monitoring Project Plan maintained by the TBEP and those of the inter-agency partners. Data quality objectives followed guidelines outlined in the USEPA-approved TBEP Data Quality Management Plan (Sherwood et al., 2020). Many of the local partners also participate in the Southwest Florida Regional Ambient Monitoring Program (RAMP) that ensures similar standards and protocols are followed in the collection and processing of monitoring data, including routine cross-reference of split samples between laboratories to check precision of measured values. Samples requiring laboratory analysis (e.g., nutrient assays) were obtained primarily from bottle collection at the surface, whereas in situ measurements were available for many parameters (e.g., dissolved oxygen, Secchi depth, etc.). In situ measurements were collected using common monitoring equipment, such as YSI sondes or Seabird CTD casts, depending on monitoring agency. Laboratory methods used to process samples were based on accepted procedures promoted through the Southwest Florida RAMP. Additionally, the Sentinel-3 satellites were used to derive chl-a maps, which were subsequently calibrated using field-measured chl-a in surface waters.

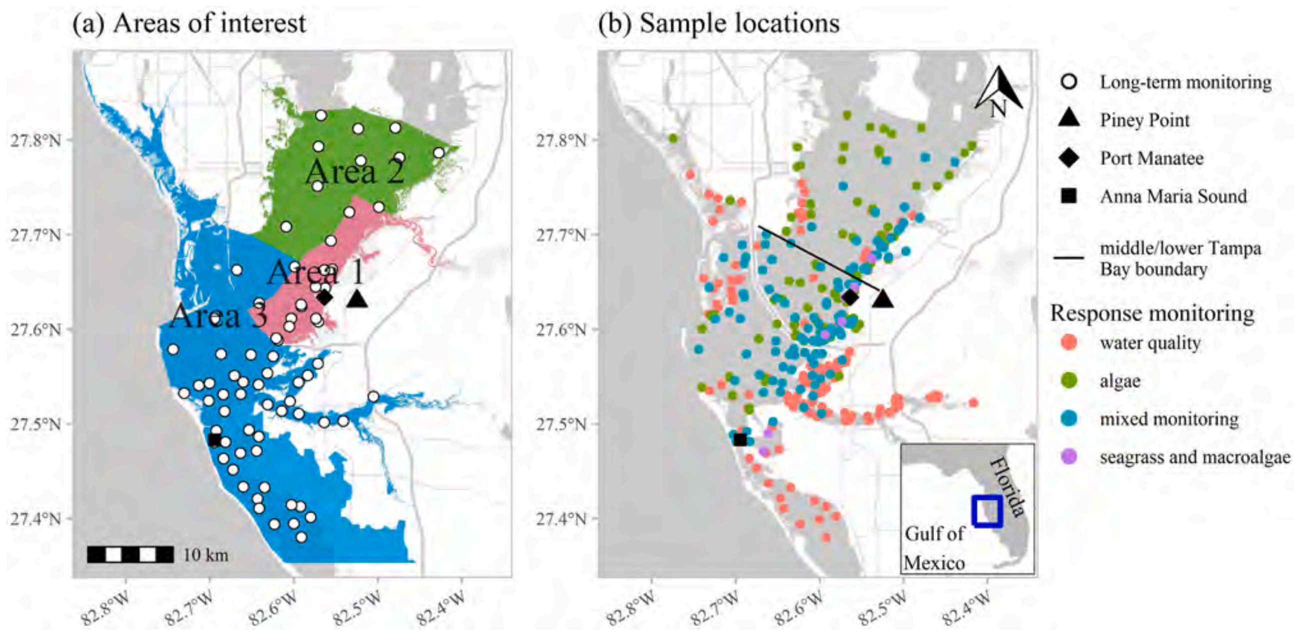

Fig. 1. Areas of interest and long-term monitoring stations (a) for evaluating status and trends in response-based monitoring data and sample locations from March through September 2021 by monitoring data type (b) in response to release from Piney Point. Data types include algae sampling, seagrass and macroalgae, water quality (field-based and laboratory samples), and mixed monitoring (algae, seagrass and macroalgae, water quality). Inset shows location of Tampa Bay on the Gulf coast of Florida, USA.

Phytoplankton samples included a mix of quantitative (cells/L) and qualitative (presence/absence) samples for major taxa at similar frequency and spatial distribution as the water quality samples. Harmful Algal Bloom (HAB) data for *Karenia brevis* were obtained from event-based monitoring samples from the FWC-FWRI HAB Monitoring Database. HAB sampling typically occurs in response to bloom events or fish kills with extensive quality control of cell counts conducted by FWC-FWRI (additional details in Stumpf et al., 2022). HAB data were restricted to Tampa Bay boundaries and over 90% of the samples were collected within one meter of the surface. Bloom sizes for *K. brevis* were described qualitatively as low/medium/high concentrations based on FWC breakpoints at 10,000/100,000/1,000,000 cells/L. Fish kill reports were obtained from the FWC online database. Seagrass and macroalgae sampling occurred approximately biweekly at 38 transects using a modified rapid assessment design, where species were identified and enumerated using Braun-Blanquet abundances in a 0.25 m^2 quadrat at 10 m distances along each 50 m transect (see supplement). Finally, precipitation and wind data were from Albert Whitted Airfield at St. Petersburg, Florida and inflow estimates to Tampa Bay were based on summed hydrologic loads of major tributaries from US Geological Survey gaged sites (similar to Janicki Environmental, Inc., 2012). Additional details of the sampling methods and data sources are provided in supplement.

2.3. Data analysis

Long-term water quality monitoring data from Hillsborough and Manatee counties (accessible at https://wateratlas.usf.edu/, Hillsborough County collected monthly, Manatee County collected quarterly) were used to establish baseline conditions for major areas of interest in Fig. 1a to compare with the response monitoring data described above. These areas (Area 1: closest to Piney Point; Area 2: north of Piney Point; Area 3: south of Piney Point including northern Sarasota Bay) were identified based on anticipated impacts from expected plume patterns following the TBCOM simulations and other prominent bay boundaries relative to Piney Point (i.e., the main shipping channel in the bay, inflow boundaries, location of the Skyway Bridge at the mouth of Tampa Bay, and major bay segments used by TBEP for assessing annual water quality targets). Observations at each long-term monitoring station were averaged for each month across years from 2006 to 2020. This period represents a “recovery” stage for Tampa Bay where water quality conditions were much improved from historical conditions during a more eutrophic period and when seagrass areal coverage was trending toward and above a 1950s benchmark target of 15,378 ha (38,000 acres, Greening et al., 2014; Sherwood et al., 2017). For each month, the mean values +/ 1 standard deviation for each parameter at each station were quantified and used as reference values relative to results at the closest water quality monitoring station that was sampled in response to Piney Point. This comparison was made to ensure that the response data were evaluated relative to stations that were spatially relevant (e.g., long-term conditions near the mouth of Tampa Bay are not the same as those in the middle of the bay) and seasonally-specific (e.g., historical conditions in April are not the same as historical conditions in July). In some cases, the nearest long-term station did not include data for every monitoring parameter at a response location and the next closest station was used as a reference. The average distance from a monitoring location in 2021 to the long-term sites was 1.6 km (see https://shiny.tbep.org/piney-point/ for a map of the matches).

The historical monitoring data were also used to model an expected seasonal pattern for water quality parameters from April to October in 2021. This was done by estimating smoothed annual and seasonal splines with Generalized Additive Models (GAMs) using data only from the “recovery” stage of Tampa Bay (2006 to 2020). GAMs were used to model time series of water quality parameters as a function of a continuous value for year (i.e., decimal year) and as an integer value for day of year. The continuous year value was modeled with a thin plate regression spline and the day of year value was modeled with a cyclic spline (following similar methods as Murphy et al., 2019). The modeled results provided an estimate of the expected normal seasonal variation that takes into account a long-term annual trend. Differences in the observed values sampled in the April to October time periods from the “forecasted” predictions of the baseline GAMs through 2021 provided an assessment of how the current data may have deviated from historical and normal seasonal variation.

Statistical assessments were conducted only on TN, chl-a, and Secchi disk depth as a general analysis of potential patterns in eutrophication in nitrogen-limited systems. Spatial comparisons were based primarily on the three areas identified in Fig. 1a. Variables with log-normal distributions were $\log_{10}$-transformed (i.e., nutrients, chl-a) prior to analysis. Only the water quality data from FDEP were used for statistical analysis given the consistency of sample location and collection dates. Secchi observations that were visually identified on the bottom (71 of 431 observations in the FDEP data) were removed from analysis. Observations for other parameters that were below laboratory standards of detection were evaluated with methods described below.

Differences in observations between months for April to September for water quality, seagrass, and macroalgae within each area (Fig. 1a) were evaluated using a Kruskal-Wallis one-way analysis of variance (ANOVA) followed by multiple comparisons using 2-sided Mann-Whitney *U* tests (Hollander et al., 2013). These tests were used to statistically characterize the temporal progression of changes in the bay following release from Piney Point, e.g., were July conditions significantly different from April? Probability values were adjusted using the sequential Bonferroni method described in (Holm, 1979) to account for the increased probability of Type I error rates with multiple comparisons. An adjusted p-value $< 5\%$ ($\alpha = 0.05$) was considered a significant difference between months. For water quality variables, monthly averages from long-term monitoring data were subtracted from 2021 observations to account for normal seasonal variation not attributed to potential effects from Piney Point. Similar corrections were not done for monthly comparisons of seagrass and macroalgae data because comparable long-term seasonal data do not exist. Frequency occurrence estimates were used to evaluate macroalgae and seagrasses as a standard metric used in previous analyses in Tampa Bay (Johansson, 2016; Sherwood et al., 2017). Methods used to accommodate measured concentrations of water quality variables that were below detection included summary statistics (e.g., median, mean, and standard deviation) following estimates of the empirical cumulative distribution functions for each parameter using the Kaplan-Meier method for censored data (Helsel, 2005; Lee, 2020).

The R statistical programming language (v4.0.2) was used for all analyses (R Core Team, 2021). We imported data using the googlesheets4 (Bryan, 2020) and googledrive (D'Agostino McGowan and Bryan, 2020) R packages and used tidyverse (Wickham et al., 2019) packages to format data for analysis. The tbeptools R package (Beck et al., 2021b) was used to import and summarize long-term monitoring data (EPC water quality data and seagrass transect data). The NADA R package (Lee, 2020) was used for analysis of censored data. All spatial analyses were done using the simple features (sf) R package (Pebesma, 2018). The mgcv R package (Wood, 2017) was used to create the GAMs for water quality parameters. All datasets used in this study are available from an open access data archive hosted on the Knowledge Network for Biocomplexity (Beck, 2021). Materials for reproducing the analyses, figures, tables, and other content in this paper are provided in a GitHub repository. Finally, the Piney Point Environmental Monitoring Dashboard can be used to view all data included in this paper through an interactive, online application (Beck et al., 2021a). Links and details are provided in supplement.

3. Results

3.1. Water quality trends

Water quality conditions in the northern gypstack measured in 2019 and measured directly at the point of discharge in 2021 showed concentrations that were generally much higher for key water quality parameters as compared to baseline conditions in Tampa Bay (Table 1). Notably, total ammonia nitrogen was measured at 210 mg/L at Piney Point and in the discharge, compared to a long-term median of 0.02 mg/L in lower Tampa Bay. Similar differences for total phosphorus, TN, and chl-a were observed when comparing stack conditions with those of the ambient conditions in Tampa Bay.

Table 1
Measured concentrations from the phosphogypsum stack (NGS-S) at Piney Point from a 2019 sample and samples from April 2021 for relevant water quality variables. Values are compared to normal annual medians (min, max) for concentrations in lower Tampa Bay. Normal medians are based on data for a baseline period from 2006 to 2020 from long-term monitoring stations in lower Tampa Bay (Fig. 1a). The 2021 samples are from the NGS-S stack on April 13th and directly from the outflow site at Port Manatee on April 6th. Missing values were not measured in the stack water or release water.

Water quality variable	2019 stack value	2021 stack value	2021 pipe value	2006–2020 lower Tampa Bay median (min, max)
Nitrate/Nitrite (mg/L)	0.004	0.292	0.004	0.012 (0.007, 0.014)
NH3, NH4+ (mg/L)	210	–	210	0.019 (0.007, 0.039)
TN (mg/L)	230	–	220	0.288 (0.226, 0.385)
TP (mg/L)	160	161	140	0.082 (0.058, 0.145)
Ortho-P (mg/L)	150	155	140	0.049 (0.029, 0.055)
DO (% sat.)	107.5	–	–	90.7 (86, 92)
pH	4	–	–	8.1 (8, 8.1)
Chl-a (μg/L)	–	105	–	3.1 (2.3, 3.5)

Samples collected in the bay between April through September 2021 indicated that water quality conditions were outside of normal values expected for each month. A total of 7831 samples were collected and analyzed for chl-a, dissolved oxygen, TN, total phosphorus, total ammonia nitrogen, nitrate/nitrite, pH, salinity, Secchi depth, and temperature (Table 2). The percentage of observations outside of the normal range (mean +/ 1 standard deviation from long-term data) varied by location and parameter. For chl-a, 50% of the observations from April through September were above the normal range for Area 1 located closest to the discharge point, whereas only 6% and 22% were above for Areas 2 (to the north) and 3 (to the south), respectively. TN concentrations were above the normal range for 37% of observations in Area 1, whereas concentrations were above for 22% of observations in Area 2 and 22% in Area 3. Secchi observations were below the normal range for 41% of observations in Area 1 and for 18% and 36% of observations in Areas 2 and 3. Notable differences were also observed for dissolved oxygen (e.g., 53% were above in Area 1, 44% in Area 2). Physical parameters (salinity, temperature) and inorganic nitrogen (ammonia, nitrate/nitrite) were more often in normal ranges, although initial time series showed much higher concentrations for ammonia in April near Area 1. Ammonia concentrations near the point of discharge were observed in excess of 10 mg/L in April, about three orders of magnitude above baseline (Figs. S2, S3), similar to the discharge measurements in Table 1. Inorganic nitrogen did not persist at high concentrations past April as it was likely rapidly utilized by phytoplankton (see below). Spatial variation among the parameters showed that values were generally above the normal range (or below for Secchi depth) for many locations near Piney Point (Area 1), Anna Maria Sound (Area 3), and the northern mouth of Tampa Bay (Area 3, Fig. 2).

TN, chl-a, and Secchi depth followed temporal progressions in 2021 that were distinct from long-term seasonal trends estimated from historical data (Fig. 3). For Area 1, TN and chl-a concentrations were frequently above normal ranges during April. Chl-a concentrations were observed in excess of 50 μg/L, although median concentrations for each week in April were <10 μg/L. The initial chl-a peak was associated with a localized phytoplankton bloom generally dominated by diatoms. The initial diatom bloom did not persist past April. Chl-a concentrations decreased slightly until June and July when values increased again above the seasonal expectation, coincident with an increase in *K. brevis* concentrations to bloom levels. Many Secchi observations in Area 1 were

Table 2
Summary of water quality variables collected in Tampa Bay from April through September 2021 following the release of water from Piney Point. Variables are grouped by major areas of interest for evaluating status and trends shown in Fig. 1a. Summaries are median, minimum, and maximum values. Total observations (N obs.) and the percentage of observations in range, above, or below normal ranges are also shown. Normal ranges are defined as within ±1 standard deviation of the mean for the month of observation from 2006 to 2020 for values collected at the nearest long-term monitoring site to each sample location. The final column shows the percentage of total observations that were outside of detection, defined as minimum laboratory detection limits for all parameters and values on the bottom for Secchi observations. Medians denoted by "–" could not be calculated due to insufficient values above detection.

Area	Water quality variable	Med. (min., max.)	N obs.	% in range	% above	% below	% outside detection
1	Chl-a (μg/L)	4.3 (1.1, 265.01)	485	44	50	6	0
	DO (% sat.)	97.9 (28.3, 215.3)	430	30	53	17	0
	NH3, NH4+ (mg/L)	0.005 (0, 14.86)	495	66	18	17	26
	Nitrate/ Nitrite (mg/L)	0 (0, 0.14352)	517	63	19	18	70
	pH	8.1 (6.8, 9.1)	476	58	29	14	0
	Sal (ppt)	30.2 (12.9, 34.6)	441	83	4	13	0
	Secchi (m)	2.4 (0.4, 9.5)	350	37	22	41	25
	Temp (C)	25.5 (19.6, 32.9)	442	66	15	19	0
	TN (mg/ L)	0.41 (0.178, 5.6)	429	59	37	4	4
	TP (mg/ L)	0.12 (0.019, 3.9)	485	81	15	4	1
2	Chl-a (μg/L)	2.7 (1.08, 42)	78	60	6	33	0
	DO (% sat.)	95 (60.6, 153.3)	73	42	44	14	0
	NH3, NH4+ (mg/L)	0.004 (0.002, 0.071)	76	86	1	13	21
	Nitrate/ Nitrite (mg/L)	– (0.00078, 0.037)	87	63	18	18	79
	pH	8 (7.3, 8.6)	92	72	16	12	0
	Sal (ppt)	27.3 (18.1, 32.3)	73	90	0	10	0
	Secchi (m)	2 (0.5, 3.5)	44	41	41	18	39
	Temp (C)	25.3 (19.9, 31.6)	73	73	7	21	0
	TN (mg/ L)	0.344 (0.068, 1.13)	63	65	22	13	14
	TP (mg/ L)	0.1 (0.05, 0.235)	67	60	12	28	0
3	Chl-a (μg/L)	2.9 (0.93, 25.9)	254	69	22	9	0
	DO (% sat.)	98.7 (42.4, 229.9)	223	53	26	21	0
	NH3, NH4+ (mg/L)	0.003 (0.002, 0.041)	248	55	0	45	50
	Nitrate/ Nitrite (mg/L)	– (0.00078, 0.046)	267	60	9	31	89
	pH	8.1 (6.2, 9.8)	245	70	21	9	0
	Sal (ppt)	31.8 (1.4, 36.5)	294	81	8	11	0
	Secchi (m)	1.9 (0.2, 5.5)	225	46	17	36	11
	Temp (C)	27 (19.6, 32.1)	294	64	13	24	0
	TN (mg/ L)	0.33 (0.152, 1.78)	249	73	22	5	10
	TP (mg/ L)	0.06 (0.019, 0.589)	256	78	11	12	17

lower than normal in April and July. Observations in Areas 2 and 3 were more often within the normal seasonal range, with some exceptions for TN and chl-a in Area 3 in April, May, and July. These field-based observations were in line with remotely-estimated chl-a using satellite observations. These observations showed an initial bloom on April 5, which peaked on April 9 with a bloom area of about 25 km^2 (about 10 km alongshore and 2.5 km cross-shore) in Area 1 of Fig. 1a, with chl-a ranging between 5 and 40 μg/L. The bloom disappeared on April 12 but reappeared on April 15 at the same location, then disappeared after April 22. Notably, similar blooms at this location were not observed from satellite in the month of April since Sentinel-3 satellite data became available in 2016. Clearly, the bloom was induced by the wastewater discharge, but localized and also short lived.

Statistical comparisons between months for seasonally-corrected observations of TN, chl-a, and Secchi depth (Table 3) supported the results in Fig. 3. Kruskal-Wallis tests that assessed if at least one of the months had significantly different observations for each parameter were significant ($p < 0.05$) for TN, chl-a, and Secchi depth for Areas 1 and 3 and for TN and chl-a for Area 2 (Table 3). Further analysis with multiple comparison tests generally showed that April/May were different from June/July depending on Area and parameter, such that observations in the later months were generally higher (or lower for Secchi) corresponding to increasing *K. brevis* abundances by mid-summer.

3.2. Macroalgae and seagrass trends

A total of 38 transects were sampled for macroalgae and seagrass from April through September, each visited on average 1.7 times per month. Macroalgae observed along the transects varied in coverage, with red macroalgae groups having the highest frequency occurrence of 57%. Common taxa in the red group included genera *Gracilaria* and *Acanthophora*. Green macroalgae and filamentous cyanobacteria were less common, with frequency occurrences of 7% and 13%. Common taxa in the green group included genera *Ulva* and *Caulerpa*, whereas cyanobacteria biomass was dominated by the benthic filamentous genus *Dapis*. Brown macroalgae (primarily in the genus *Feldmannia*) were only observed at one transect in April (2% frequency occurrence). For seagrasses, turtle grass (*Thalassia testudinum*) was the dominant species with frequency occurrence of 50% across all locations and sample dates. Manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*) had similar coverage across all transects, with frequency occurrences of 31% and 33%, respectively. The frequency occurrences of seagrasses near Piney Point were similar to the long-term record of seagrass transect data available for Tampa Bay (Sherwood et al., 2017, also see https://shiny.tbep.org/seagrasstransect-dash), with turtle grass being the dominant species in more euhaline waters closer to the Gulf. There is no historical macroalgae record for Tampa Bay that is comparable to the spatial and temporal resolution of the 2021 samples. Only annual historical data are available for seagrasses, with no seasonal data comparable to the results herein.

A typical temporal pattern for macroalgae and seagrass observed at

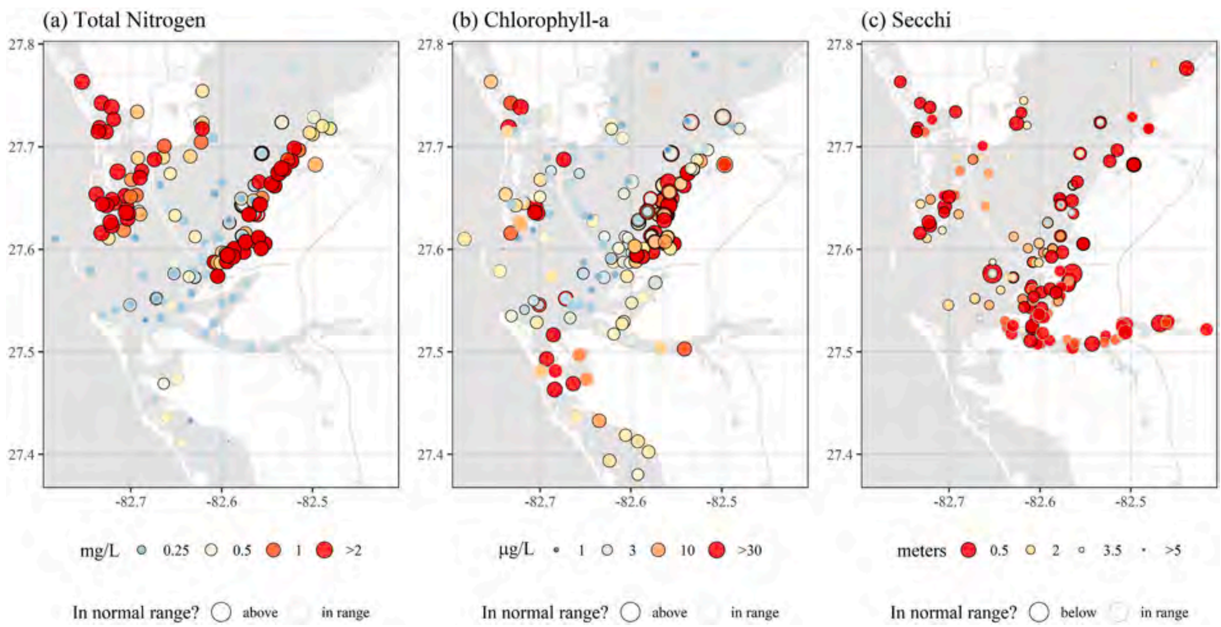

Fig. 2. Water quality data (raw observations) for April through September 2021 following the release from Piney Point for (a) total nitrogen (mg/L), (b) chlorophyll-a (μg/L), and (c) Secchi disk depth (meters). Values outside of the normal range (above for total nitrogen and chlorophyll-a, below for Secchi) are outlined in black and those in normal range are outlined in light grey. Color ramps and point sizes show relative values (reversed for Secchi). Normal ranges are defined as within ±1 standard deviation of the mean for the month of observation from 2006 to 2020 for values collected at the nearest long-term monitoring site to each sample location (Fig. 1a). Values below detection limits (or Secchi on bottom) are not shown. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

many of the transects is shown in Fig. 4, using transect S3T6 near Port Manatee as an example. Macroalgal abundances changed over the course of sampling similar to the remainder of transects sampled during the study. Red macroalgae were present in high abundances from April to May. Filamentous cyanobacteria (*Dapis* spp.) mats were first observed on May 24th and was present at all of the sample locations along this transect on June 4th and 15th. Filamentous cyanobacteria persisted through June and July, but was not observed in abundance after July 20th. Green macroalgae taxa were first observed in July, although at generally low abundances. Red macroalgae were the dominant taxa by the end of September. Overall abundance of seagrass did not change from April 22nd through September. The site is dominated by manatee grass that was observed at nearly all of the sample points along the transect at varying coverages.

Monthly summaries in frequency occurrence by area (Fig. 5) provided an indication of macroalgae and seagrass trends in 2021 across all transects. No transects were sampled in Area 2 to the north of Piney Point and no transects were sampled past September in Area 1 given allocated sampling effort following projected dispersal patterns of the discharge from the TBCOM simulations. Red macroalgae was the dominant group across all months and areas, with the highest frequency occurrences observed in April (81% in Area 1, 95% in Area 3). Reductions in red macroalgae frequency occurrence were observed in June when cyanobacteria frequency occurrence peaked, with greater coverage of cyanobacteria in Area 3 (43%) compared to Area 1 (36%). Notable blooms of the filamentous cyanobacteria (*Dapis* spp.) were observed in Anna Maria Sound (Area 3) and near Port Manatee (Area 1) (Fig. 1), typically observed covering benthic and seagrass habitats, in addition to large floating mats on the surface. Green macroalgae had the second lowest frequency occurrence, although it increased slightly by the end of the study period (9% in September in Area 1, 31% in October in Area 3). For seagrass, both areas had generally stable total frequency occurrence. Turtle grass (*T. testudinum*) occurred in higher frequency occurrence in both areas (45% overall in Area 1, 58% overall in Area 3), compared to shoal grass (*H. wrightii*, 31% Area 1, 38% Area 3) and manatee grass (*S. filiforme*, 30% Area 1, 31% Area 3). Slight changes in frequency occurrence in Area 3 were observed for all species starting in July, with a slight reduction in frequency occurrence of turtle grass and an increase in shoal grass and manatee grass. Statistical analyses with multiple comparison tests confirmed the general trends described above, with significant changes observed over time only for macroalgae (Tables S1, S2). Tests using Braun Blanquet cover estimates confirmed the results from the frequency occurrence estimates (Tables S3, S4).

3.3. *Red tide impacts*

On April 20th, the HAB species *Karenia brevis* was observed near Anna Maria Sound at the southern edge of the mouth of Tampa Bay. This first Tampa Bay influx likely originated from an ongoing coastal bloom in the Gulf of Mexico, as is common when red tide is observed in the bay (Flaherty and Landsberg, 2011; Steidinger and Ingle, 1972). By May 23, bloom concentrations of *K. brevis* were observed in lower Tampa Bay (lower/middle bay boundary Fig. 1b), with concentrations peaking (10^6 to 10^7 cells/L) by the week of July 4th in middle Tampa Bay, after which concentrations declined (Fig. 6b). The increase in *K. brevis* from April to July was an anomaly in 2021 that is not regularly observed in Tampa Bay. The historical record from 1953 to present (Fig. 6a) shows cell concentrations sampled in Tampa Bay between April and September, with only a few years having cell concentrations $>10^5$ cells/L, notably 1963, 1971, 2005, 2018, and 2021. Median cell concentrations for most years were well below 1000 cells/L. The two highest concentrations in the long-term record were observed in 1971 (20 million cells/L) and 2021 (17.6 million cells/L), both being over an order of magnitude above the high category. Cumulative rainfall and associated inflow from the main rivers entering Tampa Bay in 2021 were below historical values (2006–2020) in the months preceding the highest bloom concentrations (i.e., January to June, Fig. 6c, d). This likely contributed to elevated salinity in lower and middle Tampa Bay that created conditions favorable for *K. brevis* growth in 2021 (Figs. S2f, S3f), in addition to the elevated nutrient concentrations from the Piney Point discharge.

Fish kill reports attributed to *K. brevis* at the cities of Tampa and Saint Petersburg, FL closely tracked cell concentrations during June and July

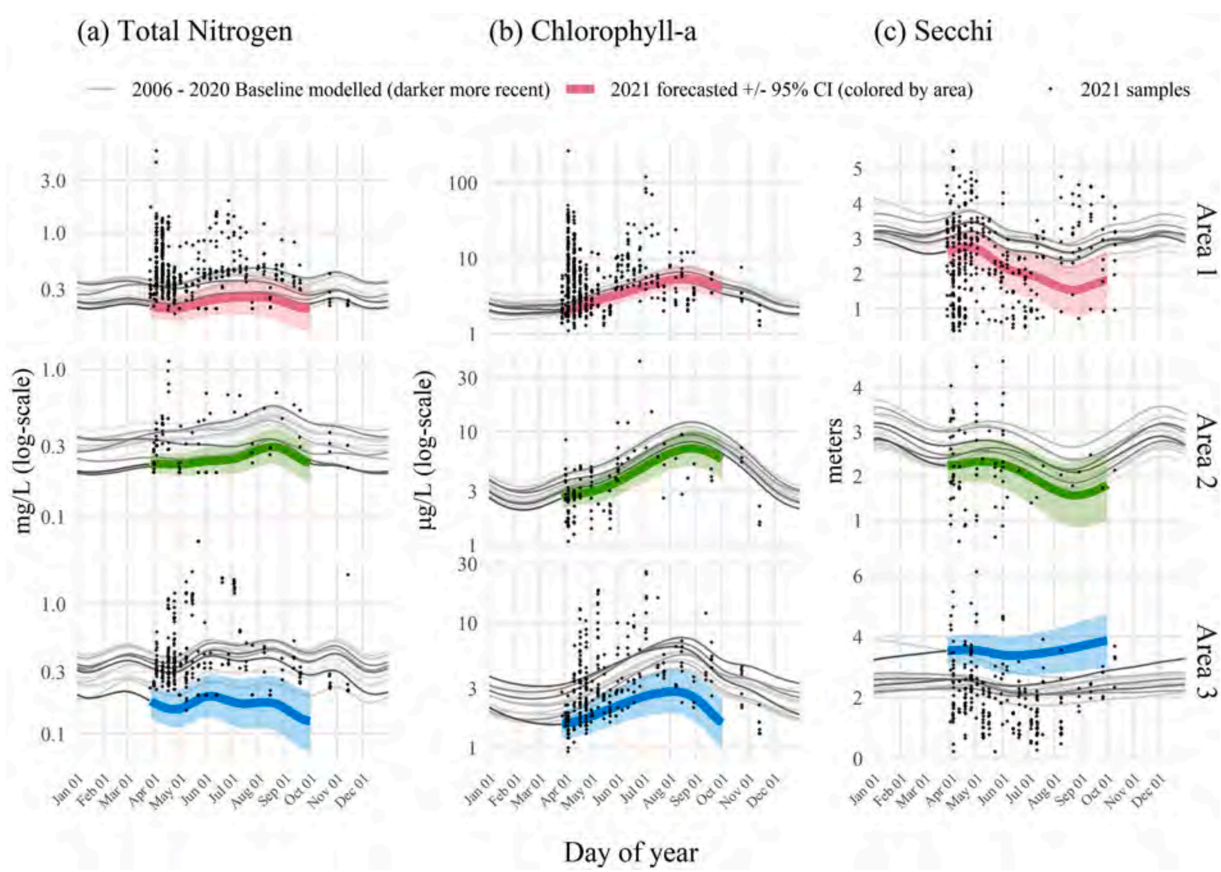

Fig. 3. Expected 2021 (a) total nitrogen (mg/L), (b) chlorophyll-a (µg/L), and (c) Secchi disk depth (meters) by area based on historical seasonal models. Predictions (expected values) from the historical models for dates during and after the Piney Point release are shown in thick lines (+/−95% confidence), with observed samples overlaid on the plots to emphasize deviation of 2021 data from historical seasonal estimates. Expected values are based on Generalized Additive Models fit to historical baseline data from 2006 to early 2021, where historical predictions are shown as thin grey lines, with darker lines for more recent years. Results are grouped by assessment areas shown in Fig. 1a.

2021 (Fig. 6e). In total, 331 reports were made in Saint Petersburg and 65 in Tampa. The combined weekly reports in 2021 for Tampa and Saint Petersburg peaked the week of July 4th, the same week as the peak of *K. brevis* cell concentrations (Fig. 6b). Notably, all of the fish kill reports occurred within a 1.5 month period when *K. brevis* cell concentrations were consistently above the medium threshold (10^4 cells/L). The center of Tropical Storm Elsa (Fig. 6f, pre-, post-storm wind roses) also passed through the bay area on July 5th, causing a shift in winds that likely disturbed the water column and altered the spatial distribution of *K. brevis* in the bay. Strong southeasterly winds also likely moved dead fish closer to heavily populated areas of Tampa Bay, specifically near St. Petersburg and Tampa, contributing to an increase in fish kill reports. It is important to note that high cell concentrations (>10^6 cells/L) were observed in middle Tampa Bay (Fig. 6b) and fish kills were reported both before and after storm passage (Fig. 6e). By August, cleanup efforts removed over 1600 metric tons of dead fish near public and private shoreline areas (K. Hammer Levy, Pinellas County, pers. comm. Aug. 2021).

4. Discussion

The observed conditions in Tampa Bay in 2021 following releases from Piney Point provide multiples lines of evidence for an adverse environmental response to a large pulse of inorganic nitrogen into the system. Collectively, these observations show that conditions in 2021 were anomalous when compared to long-term monitoring data for Tampa Bay, although some of the anomalies may not be related to the Piney Point release. These anomalous events (Fig. 7) included 1) a large diatom bloom (~25 km^2, chl-a between 5 and 40 µg/L) in April in the vicinity of the release at Port Manatee, 2) high abundance of filamentous cyanobacteria in Anna Maria Sound and near Port Manatee, 3) medium to high bloom concentrations of the ride tide organism *K. brevis* in lower and middle Tampa Bay from June through July, and 4) high incidence of fish kill reports prompting local governments to remove over 1600 metric tons of dead fish from shoreline areas. The water quality conditions observed during the study period, particularly for TN, chl-a, and Secchi depth, were outside of normal seasonal ranges for many of the observations (Fig. 2, Table 2). The Piney Point event also represented an anomalous volume and load of labile nitrogen released directly into lower Tampa Bay. Spill events reported to FDEP (e.g., industrial spills, service line failures, sanitary sewer overflows) provide additional context for Piney Point relative to other potential anomalous releases to Tampa Bay. An assessment of over 800 reports to FDEP for the Tampa Bay watershed over the last five years showed spill volumes for these events are small (median volume 13.7 thousand liters TBEP unpublished analysis) compared to the 814 million liters released from Piney Point. Moreover, the estimated nutrient load of 186 metric tons of nitrogen to Tampa Bay from Piney Point over the ten day period, exceeded current annual estimates of all external loading sources into lower Tampa Bay (Janicki Environmental, Inc., 2017). External nitrogen loads to lower Tampa Bay averaged 164 metric tons per year for the baseline period of 2006 to 2020 (https://tbep-tech.github.io/load-estimates/).

4.1. Potential nutrient cycling

The events of 2021 can be considered together to develop a narrative

Table 3
Comparison of total nitrogen, chlorophyll-a, and Secchi depth by areas of interest (Fig. 1a) and month. Overall significance of differences of concentrations between months for each water quality variable and area combination are shown with Chi-squared statistics based on Kruskall-Wallis rank sum tests. Multiple comparisons with Mann-Whitney U tests (Comp. column) were used to evaluate pairwise monthly concentrations for each water quality variable in each area. Rows that share letters within each area and water quality variable combination have concentrations that are not significantly different between month pairs. All statistical tests were performed on the seasonally-corrected water quality values that were based on observations with the long-term monthly median subtracted (observed medians are shown for comparison). **$p < 0.005$, *$p < 0.05$, blank is not significant at α 0.05.

Area	Water quality variable	Chi-Sq.	Comp.	Month	N obs.	Observed median	Seasonally-corrected median
1	TN (mg/L)	25.01**	a	Apr	135	0.390	0.008
			b	May	32	0.360	0.110
			ab	Jun	38	0.430	0.112
			b	Jul	24	0.520	0.178
			ab	Aug	25	0.470	0.065
			ab	Sep	8	0.390	0.075
	Chl-a (μg/L)	61.84**	a	Apr	144	3.300	1.010
			b	May	32	2.400	0.870
			a	Jun	38	6.600	1.960
			a	Jul	24	5.600	0.310
			c	Aug	27	3.300	3.590
	Secchi (m)	47.47**	a	Apr	118	2.900	0.000
			b	May	28	3.000	0.600
			b	Jun	34	2.000	0.900
			b	Jul	18	2.000	0.700
			c	Aug	15	3.500	0.400
			c	Sep	12	3.600	0.900
2	TN (mg/L)	20.85**	a	Apr	18	0.390	0.002
			b	May	4	0.390	0.160
			ab	Jun	3	0.500	0.113
			ab	Jul	3	0.510	0.097
			ab	Aug	3	0.540	0.174
			ab	Sep	1	0.570	0.049
	Chl-a (μg/L)	10.76*	a	Apr	22	2.500	1.390
			a	May	4	2.150	2.590
			a	Jun	4	6.000	1.050
			a	Jul	3	7.200	0.940
			a	Aug	3	5.200	4.940
	Secchi (m)	3.82	a	Apr	17	2.000	0.200
			a	May	1	2.000	0.500
			a	Jun	3	2.100	0.700
			a	Jul	1	1.400	0.100
3	TN (mg/L)	22.13**	a	Apr	48	0.330	0.010
			b	May	16	0.335	0.079
			ab	Jun	10	0.350	0.087
			ab	Jul	12	0.365	0.043
			ab	Aug	4	0.435	0.126
			ab	Sep	7	0.380	0.023
	Chl-a (μg/L)	33.62**	ab	Apr	48	1.900	0.900
			ac	May	16	2.350	0.450
			b	Jun	12	2.800	1.580
			cd	Jul	8	4.150	0.770
			bd	Aug	4	3.200	3.100
			abcd	Sep	8	3.600	1.500
	Secchi (m)	8.77	a	Apr	41	2.700	0.000
			a	May	16	2.200	0.500
			a	Jun	12	2.200	0.400
			a	Jul	12	2.200	0.100
			a	Aug	3	2.000	0.800
			a	Sep	11	2.200	0.000

of the temporal shift of nutrient pools between ecosystem components of the bay from April through September, starting with the influx of inorganic nitrogen from Piney Point. TN concentrations first peaked in April (Fig. 8a), as did chl-a concentrations (Fig. 8b). The initial peak in water quality parameters suggested a rapid response of the phytoplankton community as an increase in diatoms (e.g., centric species, such as *Skeletonema* sp., and also *Asterionellopsis* sp., Fig. 8c) that can readily utilize inorganic forms of nitrogen that were present in the initial discharge (Bates, 1976; Domingues et al., 2011). These results were evidenced by taxonomic enumeration of phytoplankton samples collected near Port Manatee. Water quality indicators improved slightly following the decrease in diatoms in late April, as noted by relatively lower concentrations of TN and chl-a as the bloom dispersed. However, filamentous cyanobacteria biomass increased after the initial diatom bloom and peaked in June (Fig. 8d), suggesting a shift of nutrients from phytoplankton to drift macroalgae communities or changing availability of nutrient ratios creating favorable conditions for macroalgae growth (Cohen and Fong, 2006; Valiela et al., 1997). During peak macroalgae growth, TN and chl-a concentrations remained relatively low as nutrients were likely retained in macroalgae, until late June and early July when *K. brevis* concentrations peaked (Fig. 8e). The co-occurring decline in macroalgae and increase in *K. brevis* suggests a release of nutrients from the former that could have stimulated growth of the latter, although residual nutrients from the initial release from Piney Point were likely still available (Liu et al., 2021). Finally, conditions were relatively stable in August and September with relatively improved water quality conditions and no dominant algal blooms.

Our quantitative results provide some evidence to support the progression of events outlined above as a flow of nutrients over time. The distinct temporal progression can be readily identified through an

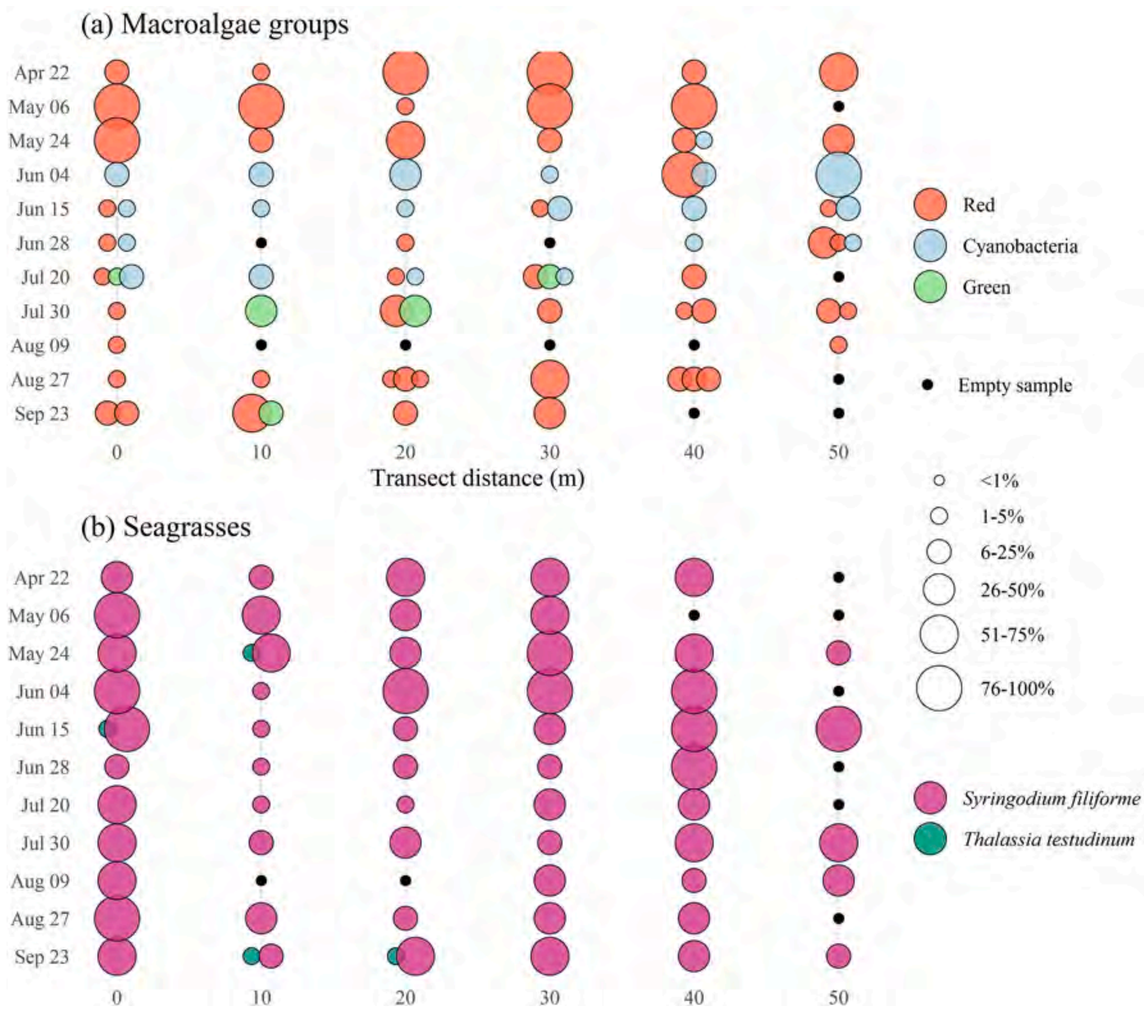

Fig. 4. Results for (a) macroalgae and (b) seagrass rapid response transect surveys at a site (S3T6, −82.55866 W longitude, 27.64483 N latitude) near Piney Point. Sample dates in 2021 are shown in rows with transect meter results shown in columns (0 m nearshore, 50 m offshore). Results show dominance of manatee grass (*Syringodium filiforme*) and red macroalgae groups, with abundances of *Dapis* spp. (cyanobacteria) peaking in June and green macroalgae (*Ulva* spp.) increasing in July. Abundances are Braun-Blanquet coverage estimates. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

ordination plot (Fig. S7) for the observed data in Fig. 8. Weekly summaries of the data are clearly separated in the ordination into monthly groups where different communities were dominant and is partially explained by orientation of the water quality vectors relative to cyanobacteria, diatoms, and *K. brevis*. For example, TN and chl-a are strongly aligned with the *K. brevis* axis as nutrients were likely available in organic form during the peak of the red tide event. However, this simple analysis only demonstrates an association in the observed data and cannot be verified without additional information. Additional data to support these results could include explicit load-based estimates for all sources entering the bay through 2021 and these estimates are forthcoming. Laboratory-based methods, such as isotopic analyses of nutrient signatures found in biological tissues (e.g., macroalgae) compared to those from the release, could provide a more comprehensive description of the recycling of nitrogen from Piney Point. Additional confounding variables can also obscure the association between water quality and community changes. Bay conditions preceding the 2021 events, as well as the passage of tropical storm Elsa, could obscure these associations (described below).

Several of the water quality responses are consistent with observations of nutrient loading in other shallow Gulf Coast estuaries (Caffrey et al., 2013; Doering et al., 2006; Greening et al., 2014). The relationship between nutrients, chl-a, and water transparency followed expectations of reduced water quality with increased nutrient loads. Temporally, these changes were observed at different times and for different species of phytoplankton. The initial increase in chl-a was first associated with a diatom bloom in April. The red tide species *K. brevis* was also first introduced to Tampa Bay from the Gulf of Mexico in April, but was not observed at high densities in the Bay until June and July. Peaks in dissolved oxygen saturation were also observed as an indicator of elevated phytoplankton production (Kemp and Boynton, 1980), particularly in July with the peak *K. brevis* bloom (Figs. S2d, S3d). Of note is that inorganic species of nitrogen, mainly ammonia, were only present at high concentrations in early April. Management concerns of the negative impacts of nutrients on water quality focused primarily on the high concentrations of ammonia in the discharge (Table 1), which can be utilized rapidly by many phytoplankton taxa (Bates, 1976; Domingues et al., 2011). Low concentrations of ammonia after April may be explained by quick uptake by the initial diatom bloom, where TN that included particulate and dissolved organic sources was at high concentrations through April and again peaked in July. Variation in observed concentrations of nutrients is complex given that high concentrations may suggest availability to support phytoplankton growth, whereas low concentrations may imply cycling of available nitrogen in organic forms already utilized by different taxa, including macroalgae (Cohen and Fong, 2006; Valiela et al., 1997).

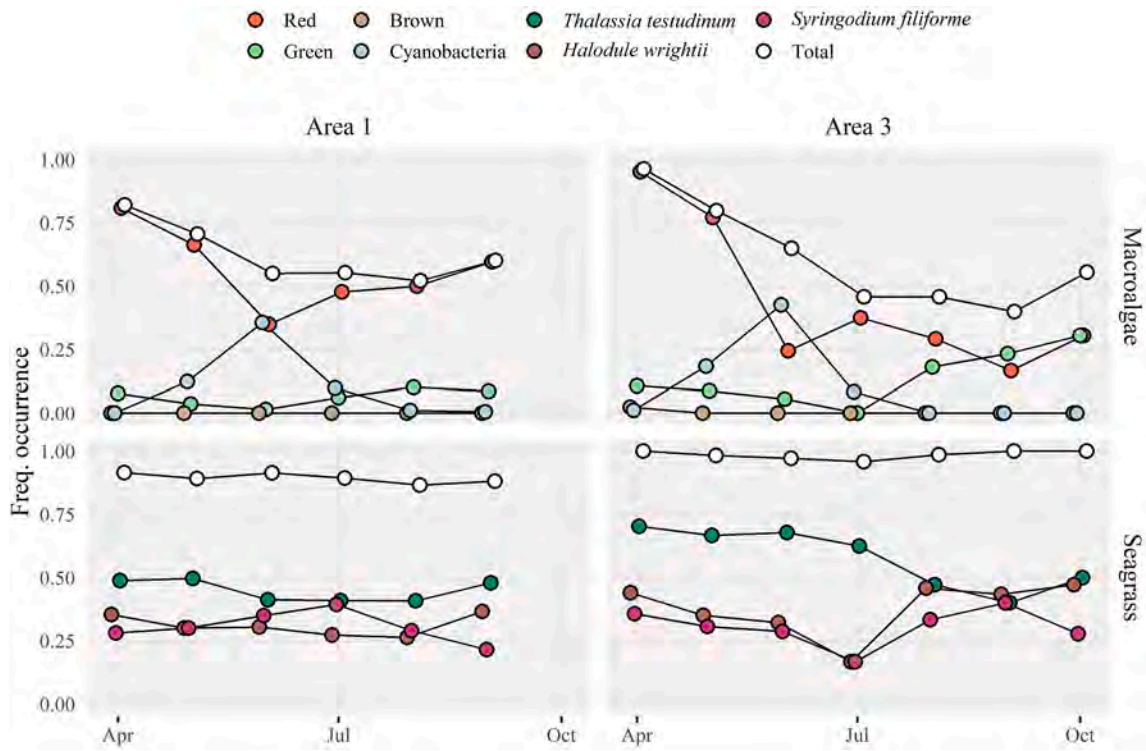

Fig. 5. Frequency occurrence estimates for (a) Area 1 and (b) Area 3 (see map Fig. 1a for locations) for macroalgae (top) and seagrass (bottom) rapid response transect surveys across all transects (n 38). Estimates are grouped by sample months in 2021. Frequency occurrences are absolute for each taxon based on presence/absence, whereas the total frequency occurrence applies to any taxa observed on each transect. Points are offset slightly for readability. No transects were sampled in Area 2 to the north of Piney Point and no transects were sampled past September in Area 1 given allocated sampling effort following projected dispersal patterns of the plume from model simulations.

4.2. Additional interpretation of impacts

Previous research for Tampa Bay has identified water quality conditions that are likely to promote seagrass growth (Greening et al., 2014, and references therein; Greening and Janicki, 2006). Water quality results in 2021 suggested that conditions may have been light-limiting for seagrass growth (e.g., high chl-a concentrations, low Secchi observations), although the conditions likely did not persist long enough to impact seagrasses. The long-term effects of the Piney Point discharge on the seagrass community remains uncertain. From 2018 to 2020, seagrass coverage declined by 16% in Tampa Bay, with similar losses observed in Sarasota Bay (18%), Lemon Bay (12%), and Charlotte Harbor (23%) to the south (Southwest Florida Water Management District, unpublished results). These broader trends suggest regional drivers are affecting seagrass communities (e.g., variation in precipitation, Tomasko et al., 2020), yet local issues specific to individual bays also pose challenges to managing water quality and subtidal habitats. Recent seagrass losses in Sarasota Bay may be linked to decreased light availability from a persistent *K. brevis* bloom in 2018. Although the 2021 red tide in Tampa Bay was short-lived, potential long-term effects on seagrasses remain a concern (e.g., alteration of sediment geochemistry, Eldridge et al., 2004). Ecosystem shifts from seagrass to macroalgae dominated communities are also a concern, both in 2021 and as observed at some locations in recent years from annual transect monitoring results for Tampa Bay. In particular, increasing abundance in recent years of the green algae *Caulerpa* sp. has been observed at long-term transects that were previously dominated by seagrass. These changes may be indicative of broader ecosystem shifts concurrent with alteration of nutrient loads or system resilience at the expense of seagrass communities (Lloret et al., 2005; Stafford and Bell, 2006). Acute stressors from short-term events, such as unanticipated releases from Piney Point, create additional and often preventable challenges to managing seagrass health.

Macroalgae trends across the study period were much more dramatic than the minimal changes observed in the seagrass community. This was expected given both the documented changes from past releases from Piney Point (Switzer et al., 2011) and the more rapid response of macroalgae to changing water quality conditions relative to seagrasses (Valiela et al., 1997). In Tampa Bay, red macroalgae groups (e.g., *Gracilaria* spp., *Acanthophora* sp.) are more common than green macroalgae (e.g., *Ulva* spp., *Caulerpa* spp.) and occur earlier in the growing season. The dominance of the red groups early in the summer followed by an increase in the green alga *Ulva* spp. may reflect a natural phenology in Tampa Bay. The most notable change in the macroalgal community in 2021 was a high abundance of filamentous cyanobacteria (i.e., *Dapis* spp.) in May and June. High abundances of *Dapis* spp. were observed in Anna Maria Sound near the mouth of Tampa Bay and near Port Manatee at the release site, which is uncommon at these locations. Long-term monitoring data describing normal seasonal variation in macroalgae are unavailable and we cannot distinguish between seasonal and inter-annual changes and those in potential response to the Piney Point release. Filamentous cyanobacteria has been observed during routine annual transect monitoring in Tampa Bay and it has previously been documented in public reports to the Florida Department of Environmental Protection. However, these communities can respond rapidly to external nutrient inputs (Ahern et al., 2007; Albert et al., 2005), often exhibiting lagged responses with characteristic growth/decay periods similar to observations herein (Estrella, 2013), and it is not unreasonable to expect these trends to be related to nutrients from Piney Point. Although long-term seasonal data are unavailable for comparison, anecdotal reports suggested that the observed biomass in 2021 was very unusual (R. Woithe, Environmental Science Associates, pers. comm. Dec. 2021).

There were also concerns that the release from Piney may have contributed to the persistence and intensity of *K. brevis*, having negative

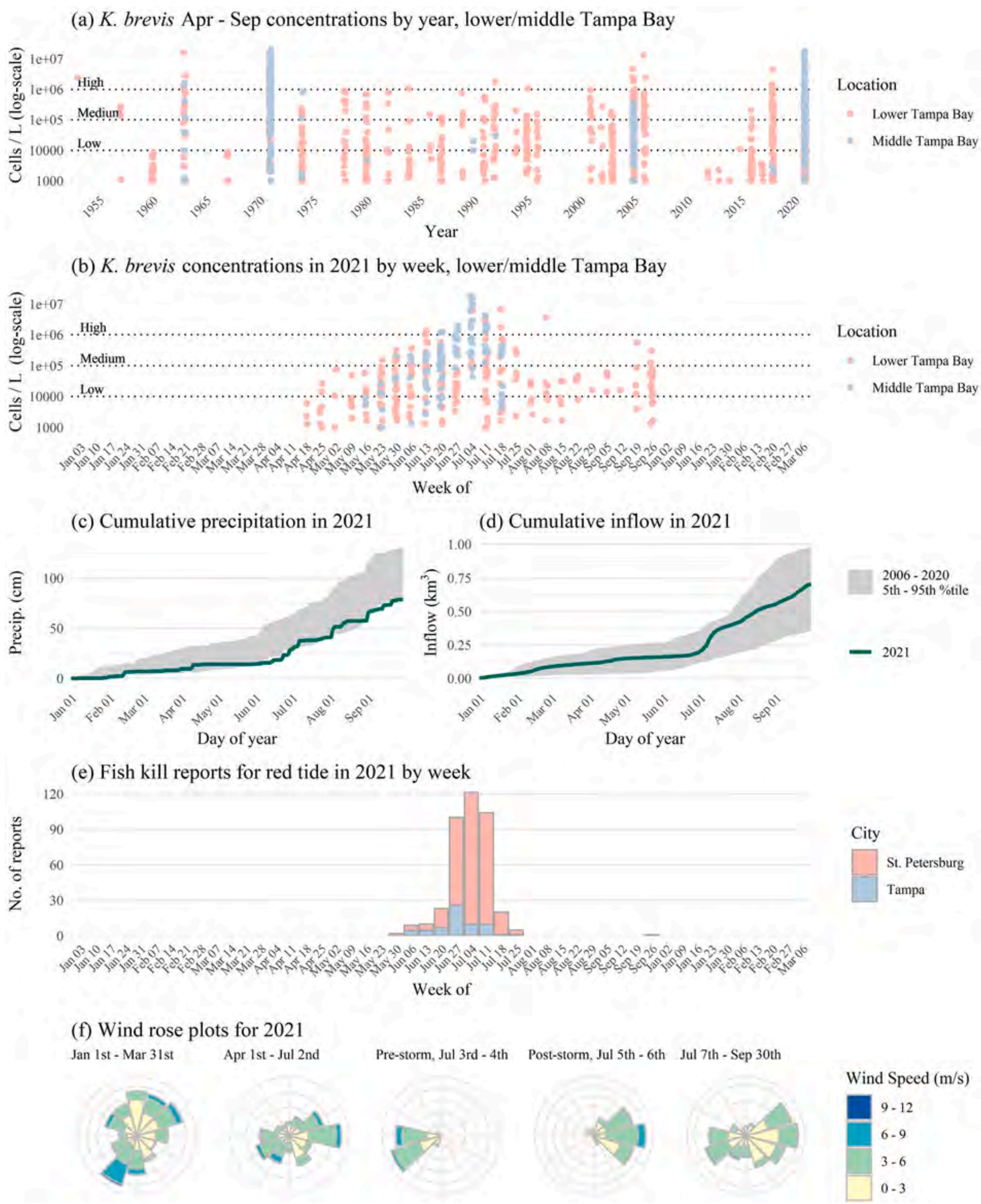

Fig. 6. *Karenia brevis* concentrations (cells/L) (a) by year and (b) by week in 2021, (c) cumulative precipitation in 2021 compared to past years, (d) cumulative inflow in 2021 compared to past years, (e) fish kill reports in 2021, and (f) wind rose plots for 2021 with notable breaks before/after Piney Point release and tropical storm Elsa. Wind roses show relative counts of six minute observations in directional (30 degree bins, north is vertical) and speed (m/s) categories.

effects on fisheries resources in June and July (Fig. 6). Fisheries resources in Tampa Bay have previously been negatively affected by red tide (e.g., in 2005, Flaherty and Landsberg, 2011; Schrandt et al., 2021). For past Piney Point events, Switzer et al. (2011) evaluated nekton communities in Bishop Harbor from November 2003 to October 2004 following discharge to this subembayment. Fish community structure and species composition did not differ compared to a pre-impact period, although HAB species (*Prorocentrum minimum*, *Heterosigma akashiwo*), including *K. brevis* and diatoms, were observed in Bishop Harbor during this time (Garrett et al., 2011). Prior blooms in Tampa Bay were more localized and *K. brevis* was at lower abundances in comparison to the 2021 bloom event, potentially mitigating exposure of fishes to related harmful conditions. In Sarasota Bay to the south, fish activity measured by passive acoustic methods was significantly lower during a 2018 red

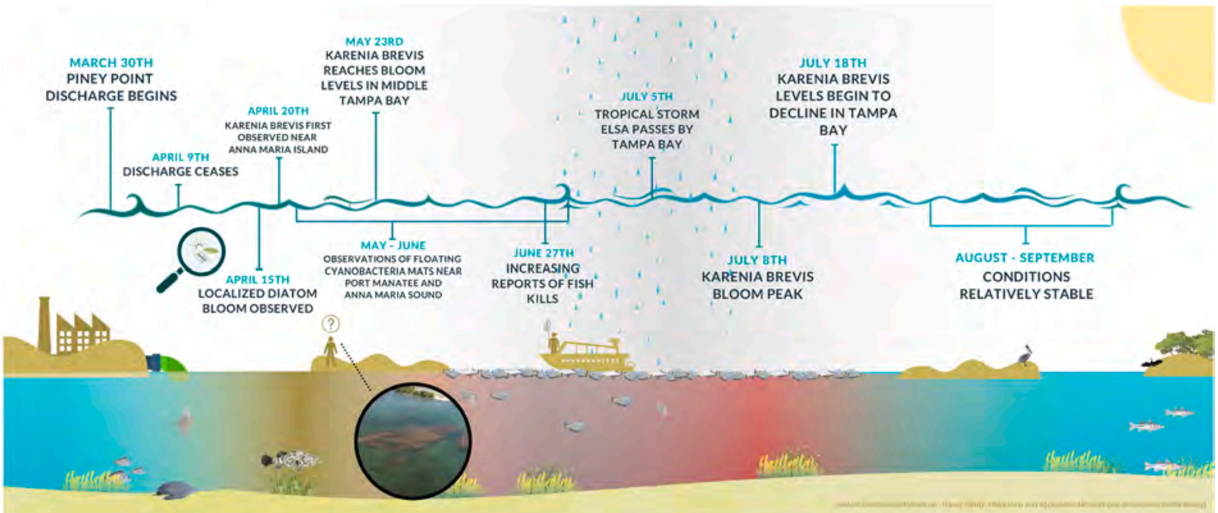

Fig. 7. Graphical timeline of events in Tampa Bay from March 30th through September 2021 following the release from Piney Point. Inset image shows blooms of filamentous cyanobacteria (*Dapis* spp.).

tide event as compared to pre-bloom levels (Rycyk et al., 2020). Water quality conditions before and after passage of tropical storm Elsa may have also contributed to fish kills by reducing bottom-water dissolved oxygen. Stevens et al. (2006) documented impacts of a category 4 storm on fish resources in the Charlotte Harbor estuary, although tropical storm Elsa was much smaller and fish kills were documented prior to and after arrival of the storm. Lack of continuous monitoring data for bottom waters in Tampa Bay prevents a more detailed assessment of impacts of the storm on water quality.

Establishing causal linkages between the nutrient inputs from Piney Point and the severity of the *K. brevis* bloom observed in Tampa Bay this year is difficult in the absence of more quantitative results or mechanistic tools to support understanding. Occurrence of this species has historically been spatially distinct, with blooms originating in subsurface water offshore on the West Florida Shelf (Liu et al., 2016; Steidinger, 1975; Weisberg et al., 2014, 2019) and occasionally occurring at bloom concentrations in lower and middle Tampa Bay. Although bloom concentrations in 2021 were extreme, historical blooms have been observed in Tampa Bay with notable events occurring in 1971 (Steidinger and Ingle, 1972), 2005 (Flaherty and Landsberg, 2011), and recently in 2018 (Skripnikov et al., 2021). Seasonal persistence in Gulf waters in southwest Florida can vary between years, with some blooms lasting as short as a few weeks, while others have been present for longer than a year (the 2018 bloom lasted sixteen months, Skripnikov et al., 2021). Severe *K. brevis* blooms are rarer in estuaries because high abundances are most common at higher salinities typical of coastal or oceanic waters (Steidinger et al., 1998; Villac et al., 2020). Contributing factors in 2021, such as low rainfall preceding the bloom and varying wind patterns, created conditions that were favorable for growth of *K. brevis* in Tampa Bay. However, the results suggest a likely scenario that residual nutrients from the Piney Point release, or indirectly through nutrients made available from the growth and decomposition of other primary producers (e.g., diatoms, macroalgae) stimulated by inputs from Piney Point, were sufficiently available to allow growth of *K. brevis* to the concentrations observed in July (also see Medina et al., 2020). Daily simulation results from the Tampa Bay Coastal Ocean Model (Chen et al., 2018, 2019) suggested that the plume was widespread throughout the bay and persisted for many months after the release ceased at Port Manatee. Plume dispersal also suggested that both open-water and back-bay habitats were exposed to nutrient concentrations sufficient to stimulate phytoplankton production. Although Piney Point did not cause red tide (i.e., it originates in the Gulf of Mexico), the events of 2021 may have created conditions in Tampa Bay conducive for the extreme bloom concentrations observed in July. Similarly, recent studies have highlighted the role of anthropogenic forcing in increasing bloom intensity in southwest Florida (Medina et al., 2020, 2022).

In the broader context of mining impacts to surface waters, these results reinforce the understanding that legacy pollutants from phosphate mining can negatively affect environmental resources. In addition to Tampa Bay (Garrett et al., 2011; Switzer et al., 2011), other Gulf Coast estuaries have been affected by pollutants from unanticipated gypstack releases. For example, two spills have occurred in Grand Bay, Mississippi, the first in 2005 following failure of the retaining walls after a heavy rain event and the second in 2012 after passage of Hurricane Isaac when the holding capacity of the local gypstack was exceeded again with heavy rainfall (Beck et al., 2018a; Dillon et al., 2015). The historical context of Grand Bay is similar to Piney Point and other international examples, e.g., Huelva estuary in Spain (Pérez-López et al., 2010, 2016). Legacy wastewater from fertilizer production has been poorly maintained at some facilities and long-term plans are insufficient to safely dispose of remnant pollutants that pose a risk of significant impacts to coastal resources that increases over time. These are not isolated examples and enhanced regulatory oversight is needed to safely and effectively close these types of facilities (Nelson et al., 2021). Local, regional, and state partners should continue to pursue management and policy actions that can mitigate the continued threats of these facilities to the health of coastal resources. These efforts are critical to managing Gulf of Mexico ecosystems given past successes and the need to address ongoing threats of climate change, human population growth, habitat loss, severe weather events, and recurring pollutant sources.

CRediT authorship contribution statement

Marcus W. Beck: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Andrew Altieri:** Data curation, Writing – review & editing. **Christine Angelini:** Conceptualization, Writing – review & editing. **Maya C. Burke:** Project administration, Supervision, Writing – review & editing. **Jing Chen:** Data curation, Writing – review & editing. **Diana W. Chin:** Data curation, Writing – review & editing. **Jayne Gardiner:** Data curation. **Chuanmin Hu:** Data curation, Writing – review & editing. **Katherine A. Hubbard:** Data curation, Validation, Writing – review & editing. **Yonggang Liu:** Data curation, Writing – review & editing. **Cary Lopez:** Data curation, Validation, Visualization, Writing – review & editing. **Miles Medina:** Formal analysis, Methodology, Visualization, Writing – review & editing. **Elise Morrison:** Data curation, Funding

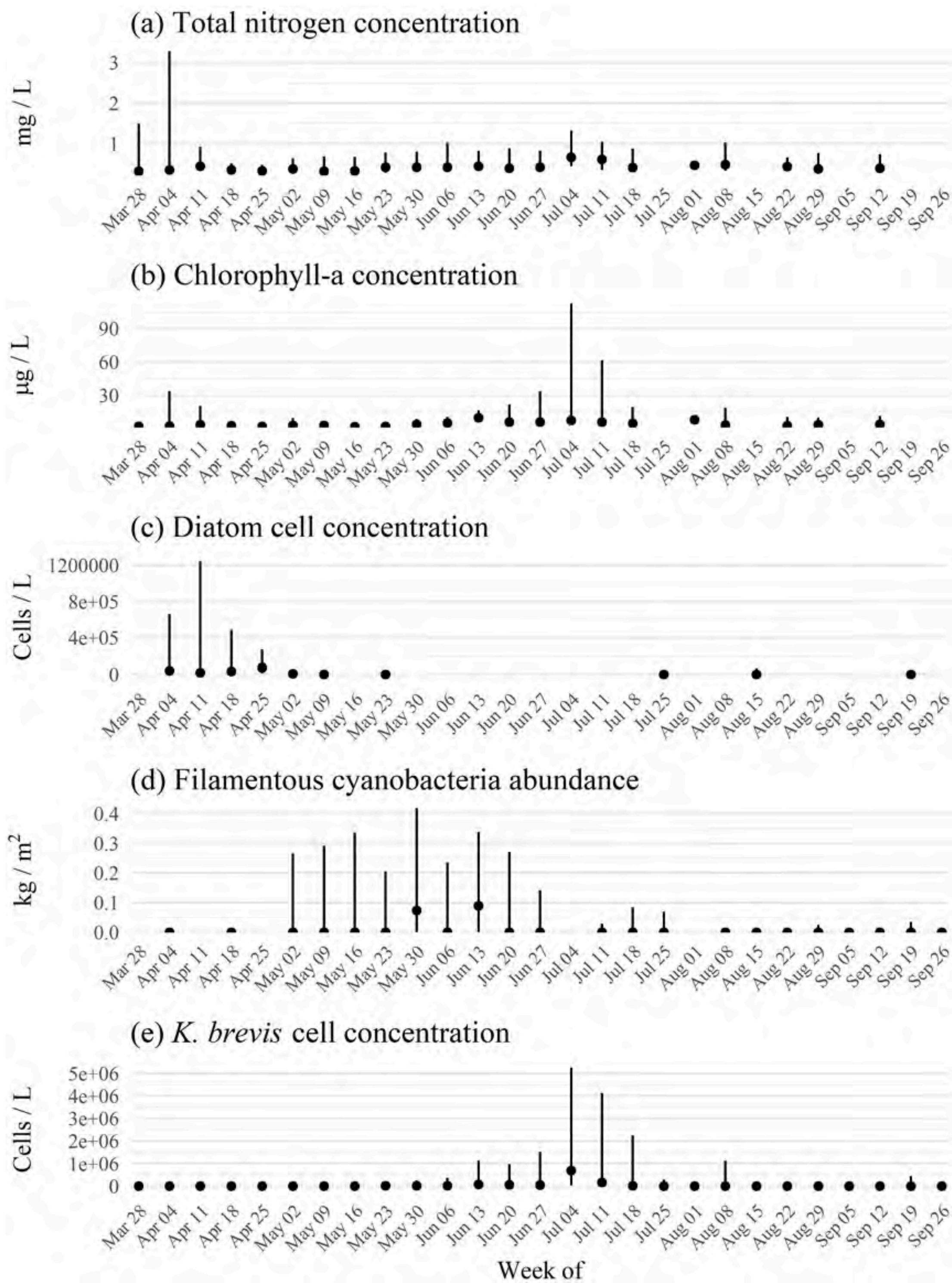

Fig. 8. Weekly summarized observations (medians, 2.5th to 97.5th percentiles) across all sampled locations for (a) total nitrogen concentrations, (b) chlorophyll-a concentrations, (c) diatom cell concentrations, (d) filamentous cyanobacteria abundances, and (e) *Karenia brevis* cell concentrations. Values are summarized for all samples within each week. The values suggest nutrient cycling between water column phytoplankton in the initial April diatom bloom, then to filamentous cyanobacteria in May to June, and then to *K. brevis* peaking in early July. The upper limit of the y-axis on (e) is truncated to emphasize trends. Quantitative cell counts for diatoms are missing for several weeks, but see Fig. S6 for frequency occurrence estimates across all dates. Diatom concentrations are based on combined cell counts from *Asterionellopsis* sp. and *Skeletonema* sp.

acquisition, Writing – review & editing. **Edward J. Phlips:** Data curation, Funding acquisition, Writing – review & editing. **Gary E. Raulerson:** Data curation, Writing – review & editing. **Sheila Scolaro:** Data curation, Writing – review & editing. **Edward T. Sherwood:** Project administration, Supervision, Writing – review & editing. **David Tomasko:** Conceptualization, Data curation, Writing – review & editing. **Robert H. Weisberg:** Data curation, Writing – review & editing. **Joseph Whalen:** Conceptualization, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2022.113598.

References

Ahern, K.S., Ahern, C.R., Udy, J.W., 2007. Nutrient additions generate prolific growth of Lyngbya majuscula (cyanobacteria) in field and bioassay experiments. Harmful Algae 6, 134–151. https://doi.org/10.1016/j.hal.2006.08.004.

Albert, S., O'Neil, J.M., Udy, J.W., Ahern, K.S., O'Sullivan, C.M., Dennison, W.C., 2005. Blooms of the cyanobacterium Lyngbya majuscula in coastal Queensland, Australia: disparate sites, common factors. Mar. Pollut. Bull. 51, 428–437. https://doi.org/10.1016/j.marpolbul.2004.10.016.

Bates, S.S., 1976. Effects of light and ammonium on nitrate uptake by two species of estuarine phytoplankton. Limnol. Oceanogr. 21, 212–218. https://doi.org/10.4319/lo.1976.21.2.0212.

Beck, M.W., 2021. 2021 piney point sampling in Tampa Bay. In: Knowledge Network for Biocomplexity. https://doi.org/10.5063/F1959G05 urn:node:KNB.

Beck, M.W., Cressman, K., Griffin, C., Caffrey, J., 2018a. Water quality trends following anomalous phosphorus inputs to Grand Bay. GulfCaribb.Res. 29, 1–14. https://doi.org/10.18785/gcr.2901.02.

Beck, M.W., Hagy III, J.D., Le, C., 2018b. Quantifying seagrass light requirements using an algorithm to spatially resolve depth of colonization. Estuar. Coasts 41, 592–610. https://doi.org/10.1007/s12237-017-0287-1.

Beck, M.W., Burke, M.C., Raulerson, G.E., Scolaro, S.C., Sherwood, E.T., Whalen, J.D., 2021. Piney Point Environmental Monitoring Dashboard. tbep-tech/piney-point: v1.0.0. Zenodo. https://doi.org/10.5281/zenodo.4666494.

Beck, M.W., Schrandt, M.N., Wessel, M.R., Sherwood, E.T., Raulerson, G.E., Prasad, A.A. B., Best, B.D., 2021b. Tbeptools: an R package for synthesizing estuarine data for environmental research. J.Open Source Softw. 6, 3485. https://doi.org/10.21105/joss.03485.

Bryan, J., 2020. googlesheets4: Access Google Sheets using the Sheets API V4. R package version 0.2.0. https://CRAN.R-project.org/package=googlesheets4.

Burnett, W.C., Elzerman, A.W., 2001. Nuclide migration and the environmental radiochemistry of Florida phosphogypsum. J. Environ. Radioact. 54, 27–51. https://doi.org/10.1016/S0265-931X(00)00164-8.

Caffrey, J.M., Murrell, M.C., Amacker, K.S., Harper, J., Phipps, S., Woodrey, M., 2013. Seasonal and inter-annual patterns in primary production, respiration and net ecosystem metabolism in 3 estuaries in the northeast Gulf of Mexico. Estuar. Coasts 37, 222–241. https://doi.org/10.1007/s12237-013-9701-5.

Chen, J., Weisberg, R.H., Liu, Y., Zheng, L., 2018. The Tampa Bay Coastal Ocean Model performance for hurricane Irma. Mar. Technol. Soc. J. 52, 33–42. https://doi.org/10.4031/MTSJ.52.3.6.

Chen, J., Weisberg, R.H., Liu, Y., Zheng, L., Zhu, J., 2019. On the momentum balance of Tampa Bay. J.Geophys.Res.Oceans 124, 4492–4510. https://doi.org/10.1029/2018JC014890.

Cohen, R.A., Fong, P., 2006. Using opportunistic green macroalgae as indicators of nitrogen supply and sources to estuaries. Ecol. Appl. 16, 1405–1420. https://doi.org/10.1890/1051-0761(2006)016[1405:UOGMAI]2.0.CO;2.

<collab>Janicki Environmental, Inc.</collab>, 2012. Development of a Screening Level Tool for Estimating Annual Hydrologic Loadings to Tampa Bay (No. 05-12). Tampa Bay Estuary Program, St. Petersburg, Florida.

<collab>Janicki Environmental, Inc.</collab>, 2017. Estimates of Total Nitrogen, Total Phosphorus, Total Suspended Solids, And Biological Oxygen Demand Loadings to Tampa Bay, Florida: 2012-2016 (No. 04-17). Tampa Bay Estuary Program, St. Petersburg, Florida.

D'Agostino McGowan, L., Bryan, J., 2020. googledrive: An interface to Google Drive. R package version 1.0.1. https://CRAN.R-project.org/package=googledrive.

Dillon, K., Caffrey, J., Carmichael, R.H., Cressman, K., Woodrey, M., 2015. Water Quality in Bangs Lake: Effects of Recurrent Phosphate Spills to a Coastal Estuary. Mississippi Water Resources Research Institute, Mississippi State, US Geological Survey, Starkville, Mississippi.

Dixon, L.K., Leverone, J.R., 1995. Light Requirements of Thalassia testudinum in Tampa Bay, Florida. Number 425. Mote Marine Lab, Sarasota, Florida.

Doering, P.H., Chamberlain, R.H., Haunert, K.M., 2006. Chlorophyll a and its use as an indicator of eutrophication in the Caloosahatchee Estuary,Florida. Florida Sci. 51–72 https://www.jstor.org/stable/24322132.

Domingues, R.B., Barbosa, A.B., Sommer, U., Galvão, H.M., 2011. Ammonium, nitrate and phytoplankton interactions in a freshwater tidal estuarine zone: potential effects of cultural eutrophication. Aquat. Sci. 73, 331–343. https://doi.org/10.1007/s00027-011-0180-0.

El Zrelli, R., Courjault-Radé, P., Rabaoui, L., Castet, S., Michel, S., Bejaoui, N., 2015. Heavy metal contamination and ecological risk assessment in the surface sediments of the coastal area surrounding the industrial complex of Gabes city, gulf of Gabes, SE Tunisia. Mar. Pollut. Bull. 101, 922–929. https://doi.org/10.1016/j.marpolbul.2015.10.047.

Eldridge, P.M., Kaldy, J.E., Burd, A.B., 2004. Stress response model for the tropical seagrass Thalassia testudinum: the interactions of light, temperature, sedimentation, and geochemistry. Estuaries 27, 923–937. https://doi.org/10.1007/BF02803419.

Estrella, S.M., 2013. Effects of Nutrient Enrichment And Toxic Lyngbya Blooms on Benthic Invertebrates And Migratory Shorebird Communities of Roebuck Bay Ramsar Site, Final Report to the NRM Office. University of Western Australia, Perth, Australia, WA.

Flaherty, K.E., Landsberg, J.H., 2011. Effects of a persistent red tide Karenia brevis bloom on community structure and species-specific relative abundance of nekton in a Gulf of Mexico estuary. Estuar. Coasts 34, 417–439. https://doi.org/10.1007/s12237-010-9350-x.

Garrett, M., Wolny, J., Truby, E., Heil, C., Kovach, C., 2011. Harmful algal bloom species and phosphate-processing effluent: field and laboratory studies. Mar. Pollut. Bull. 62, 596–601. https://doi.org/10.1016/j.marpolbul.2010.11.017.

Greening, H., Janicki, A., 2006. Toward reversal of eutrophic conditions in a subtropical estuary: water quality and seagrass response to nitrogen loading reductions in Tampa Bay, Florida, USA. Environ. Manag. 38, 163–178. https://doi.org/10.1007/s00267-005-0079-4.

Greening, H., Janicki, A., Sherwood, E., Pribble, R., Johansson, J.O.R., 2014. Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA. Estuar. Coast. Shelf Sci. 151, A1–A16. https://doi.org/10.1016/j.ecss.2014.10.003.

Helsel, D.R., 2005. Nondetects And Data Analysis: Statistics for Censored Environmental Data. John Wiley & Sons, New Jersey, USA.

Henderson, C.S., 2004. Piney Point Phosphate Plant: An Environmental Analysis. University of South Florida St, Petersburg, Florida.

Hollander, M., Wolfe, D.A., Chicken, E., 2013. Nonparametric Statistical Methods. John Wiley & Sons.

Holm, S., 1979. A simple sequentially rejective multiple test procedure. Scand. J. Stat. 6, 65–70.

Hudson-Edwards, K.A., Jamieson, H.E., Lottermoser, B.G., 2011. Mine wastes: past, present, future. Elements 7, 375–380. https://doi.org/10.2113/gselements.7.6.375.

Johansson, R., 2016. Seagrass Transect Monitoring in Tampa Bay: A Summary of Findings From 1997 Through 2015 (No. 08-16). Tampa Bay Estuary Program, St. Petersburg, Florida.

Kemp, W.M., Boynton, W.R., 1980. Influence of biological and physical processes on dissolved oxygen dynamics in an estuarine system: implications for the measurement of community metabolism. Estuar. Coast. Mar. Sci. 11, 407–431. https://doi.org/10.1016/S0302-3524(80)80065-X.

Kenworthy, W.J., Fonseca, M.S., 1996. Light requirements of seagrasses Halodule wrightii and Syringodium filiforme derived from the relationship between diffuse light attenuation and maximum depth distribution. Estuaries 19, 740–750.

Lee, L., 2020. NADA: nondetects and data analysis for environmental data. R package version 1.6-1.1. https://CRAN.R-project.org/package=NADA.

Liu, Y., Weisberg, R.H., Lenes, J.M., Zheng, L., Hubbard, K., Walsh, J.J., 2016. Offshore forcing on the "pressure point" of the West Florida Shelf: anomalous upwelling and its influence on harmful algal blooms. J.Geophys.Res.Oceans 121, 5501–5515. https://doi.org/10.1002/2016JC011938.

Liu, Y., Weisberg, R.H., Zheng, L., Sun, Y., Chen, J., 2021. Nowcast/forecast of the Tampa Bay, Piney Point effluent plume: a rapid response. In: Abstract (Os35b-1036) Presented at AGU Fall Meeting, December, 2021. New Orleans, Louisiana.

Lloret, J., Marin, A., Marin-Guirao, L., Velasco, J., 2005. Changes in macrophytes distribution in a hypersaline coastal lagoon associated with the development of intensively irrigated agriculture. OceanCoast.Manag. 48, 828–842. https://doi.org/10.1016/j.ocecoaman.2005.07.002.

Medina, M., Huffaker, R., Jawitz, J.W., Muñoz-Carpena, R., 2020. Seasonal dynamics of terrestrially sourced nitrogen influenced Karenia brevis blooms off Florida's southern Gulf Coast. Harmful Algae 98, 101900. https://doi.org/10.1016/j.hal.2020.101900.

Medina, M., Kaplan, D., Milbrandt, E.C., Tomasko, D., Huffaker, R., Angelini, C., 2022. Nitrogen-enriched discharges from a highly managed watershed intensify red tide (Karenia brevis) blooms in southwest Florida). Sci. Total Environ. 154149 https://doi.org/10.1016/j.scitotenv.2022.154149.

Murphy, R.R., Perry, E., Harcum, J., Keisman, J., 2019. A generalized additive model approach to evaluating water quality: Chesapeake Bay case study. Environ. Model Softw. 118, 1–13. https://doi.org/10.1016/j.envsoft.2019.03.027.

Nelson, N.G., Cuchiara, M.L., Hendren, C.O., Jones, J.L., Marshall, A.M., 2021. Hazardous spills at retired fertilizer manufacturing plants will continue to occur in the absence of scientific innovation and regulatory enforcement. Environ.Sci. Technol. https://doi.org/10.1021/acs.est.1c05311.

Pebesma, E., 2018. Simple features for R: standardized support for spatial vector data. R J. 10, 439–446. https://doi.org/10.32614/RJ-2018-009.

Pérez-López, R., Nieto, J.M., López-Coto, I., Aguado, J.L., Bolívar, J.P., Santisteban, M., 2010. Dynamics of contaminants in phosphogypsum of the fertilizer industry of Huelva (SW Spain): from phosphate rock ore to the environment. Appl. Geochem. 25, 705–715. https://doi.org/10.1016/j.apgeochem.2010.02.003.

Pérez-López, R., Macías, F., Cánovas, C.R., Sarmiento, A.M., Pérez-Moreno, S.M., 2016. Pollutant flows from a phosphogypsum disposal area to an estuarine environment: an insight from geochemical signatures. Sci. Total Environ. 553, 42–51. https://doi.org/10.1016/j.scitotenv.2016.02.070.

R Core Team, 2021. R: A Language And Environment for Statistical Computing, v4.1.2. R Foundation for Statistical Computing, Vienna, Austria.

Rycyk, A.M., Moore, R.B.T., Wells, R.S., McHugh, K.A., McCabe, E.J.B., Mann, D.A., 2020. Passive acoustic listening stations (PALS) show rapid onset of ecological effects of harmful algal blooms in real time. Sci. Rep. 10, 1–12. https://doi.org/10.1038/s41598-020-74647-z.

Sanders, L., Luiz-Silva, W., Machado, W., Sanders, C.J., Marotta, H., Enrich-Prast, A., Bosco-Santos, A., Boden, A., Silva-Filho, E., Santos, I.R., et al., 2013. Rare earth element and radionuclide distribution in surface sediments along an estuarine system affected by fertilizer industry contamination. Water Air Soil Pollut. 224, 1–8. https://doi.org/10.1007/s11270-013-1742-7.

Schrandt, M.N., MacDonald, T.C., Sherwood, E.T., Beck, M.W., 2021. A multimetric nekton index for monitoring, managing and communicating ecosystem health status in an urbanized Gulf of Mexico estuary. Ecol. Indic. 123, 107310 https://doi.org/10.1016/j.ecolind.2020.107310.

Sherwood, E., Greening, H., Johansson, J.O.R., Kaufman, K., Raulerson, G., 2017. Tampa Bay (Florida, USA): documenting seagrass recovery since the 1980's and reviewing the benefits. Southeast. Geogr. 57, 294–319. https://doi.org/10.1353/sgo.2017.0026.

Sherwood, E.T., Raulerson, G., Beck, M., Burke, M., 2020. Tampa Bay Estuary Program: Quality Management Plan (No. 16-20). Tampa Bay Estuary Program, St. Petersburg, Florida.

Skripnikov, A., Wagner, N., Shafer, J., Beck, M., Sherwood, E., Burke, M., 2021. Using localized Twitter activity to assess harmful algal bloom impacts of Karenia brevis in Florida, USA. Harmful Algae 110, 102118. https://doi.org/10.1016/j.hal.2021.102118.

Stafford, N.B., Bell, S.S., 2006. Space competition between seagrass and Caulerpa prolifera (Forsskaal) Lamouroux following simulated disturbances in Lassing Park, FL. J. Exp. Mar. Biol. Ecol. 333, 49–57. https://doi.org/10.1016/j.jembe.2005.11.025.

Steidinger, K.A., 1975. Implications of dinoflagellate life cycles on initiation of Gymnodinium breve red tides. Environ. Lett. 9, 129–139. https://doi.org/10.1080/00139307509435842.

Steidinger, K.A., Ingle, R.M., 1972. Observations on the 1971 summer red tide in Tampa Bay, Florida. Environ. Lett. 3, 271–278. https://doi.org/10.1080/00139307209435473.

Steidinger, K.A., Vargo, G.A., Tester, P.A., Tomas, C.R., 1998. Bloom dynamics and physiology of Gymnodium breve with emphasis on the Gulf of Mexico. In: Anderson, D.M., Cembella, A.D., Hallegraeff, G. (Eds.), Physiological Ecology of Harmful Algal Blooms. Springer-Verlag, Berlin, Heidelberg, pp. 133–151.

Stevens, P.W., Blewett, D.A., Casey, J.P., 2006. Short-term effects of a low dissolved oxygen event on estuarine fish assemblages following the passage of Hurricane Charley. Estuar. Coasts 29, 997–1003. https://doi.org/10.1007/BF02798661.

Stumpf, R.P., Li, Y., Kirkpatrick, B., Litaker, R.W., Hubbard, K.A., Currier, R.D., Harrison, K.K., Tomlinson, M.C., 2022. Quantifying Karenia brevis bloom severity and respiratory irritation impact along the shoreline of Southwest Florida. PLOS ONE 17, 1–31. https://doi.org/10.1371/journal.pone.0260755.

Switzer, T.S., Tyler-Jedlund, A.J., Rogers, K.R., Grier, H., McMichael Jr., R.H., Fox Jr., S., 2011. Response of estuarine nekton to the regulated discharge of treated phosphate-production process water. In: Florida Fish; Wildlife Conservation Commission, Fish. Wildlife Research Institute, St. Petersburg, Florida.

Tayibi, H., Choura, M., López, F.A., Alguacil, F.J., López-Delgado, A., 2009. Environmental impact and management of phosphogypsum. J. Environ. Manag. 90, 2377–2386. https://doi.org/10.1016/j.jenvman.2009.03.007.

Tomasko, D., Alderson, M., Burnes, R., Hecker, J., Iadevaia, N., Leverone, J., Raulerson, G., Sherwood, E., 2020. The effects of Hurricane Irma on seagrass meadows in previously eutrophic estuaries in Southwest Florida (USA). Mar. Pollut. Bull. 156, 111247 https://doi.org/10.1016/j.marpolbul.2020.111247.

Valiela, I., McClelland, J., Hauxwell, J., Behr, P.J., Hersh, D., Foreman, K., 1997. Macroalgal blooms in shallow estuaries: controls and ecophysiological and ecosystem consequences. Limnol. Oceanogr. 42, 1105–1118. https://doi.org/10.4319/lo.1997.42.5_part_2.1105.

Villac, M.C., Hoeglund, A., Tilney, C., Garrett, M., Lopez, C., Hubbard, K.A., Steidinger, K.A., 2020. Ecophysiology and bloom dynamics of Karenia with emphasis on Karenia brevis in Florida waters. In: Rao, D.V.S. (Ed.), Dinoflagellates: Classification, Evolution, Physiology And Ecological Significance. Nova Science Publishers, New York, pp. 261–301.

Wang, P., Martin, J., Morrison, G., 1999. Water quality and eutrophication in Tampa Bay, Florida. Estuar. Coast. Shelf Sci. 49, 1–20. https://doi.org/10.1006/ecss.1999.0490.

Weisberg, R.H., Zheng, L., Liu, Y., Lembke, C., Lenes, J.M., Walsh, J.J., 2014. Why no red tide was observed on the West Florida Continental Shelf in 2010. Harmful Algae 38, 119–126. https://doi.org/10.1016/j.hal.2014.04.010.

Weisberg, R.H., Liu, Y., Lembke, C., Hu, C., Hubbard, K., Garrett, M., 2019. The coastal ocean circulation influence on the 2018 West Florida Shelf K. brevis red tide bloom. J.Geophys.Res.Oceans 124, 2501–2512. https://doi.org/10.1029/2018JC014887.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T.L., Miller, E., Bache, S.M., Müller, K., Ooms, J., Robinson, D., Seidel, D.P., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., Yutani, H., 2019. Welcome to the tidyverse. J.Open Source Softw. 4, 1686. https://doi.org/10.21105/joss.01686.

Wood, S.N., 2017. Generalized Additive Models: An Introduction With r, 2nd ed. Chapman; Hall, CRC Press, London, United Kingdom.

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Re: Piney Point injection well UIC Permit No. 0322708-002-UC/1l, WACS Facility ID: 101607

The undersigned organizations request that you deny Manatee County's permit application as the waste at Piney Point is hazardous, whether Bevill-exempt or not, and the uncertainty of deepwell injection in this area makes the injection of waste from Piney Point a risky experiment that presents an imminent and substantial endangerment to human health and the environment. The application should be rejected as too dangerous and instead FDEP, Manatee County, and all parties involved at Piney Point should aggressively explore other proven treatment and disposal methods.

I. Piney Point Background

The Piney Point fertilizer plant consisted of an acid plant, a phosphoric acid plant, an ammoniated phosphate fertilizer plant with storage for ammonia, phosphoric acid, and other products necessary for the manufacture of fertilizer, and related facilities.

Phosphoric acid production involves the use of acidic solutions to separate phosphorus from phosphate-containing rock. The resulting waste is phosphogypsum. Phosphogypsum is watery when it is first stored, but over time it dries, and a crust forms over the top, forming "stacks." At Piney Point, this toxic waste was formed into large stacks 70-80 feet high and 457 acres wide.

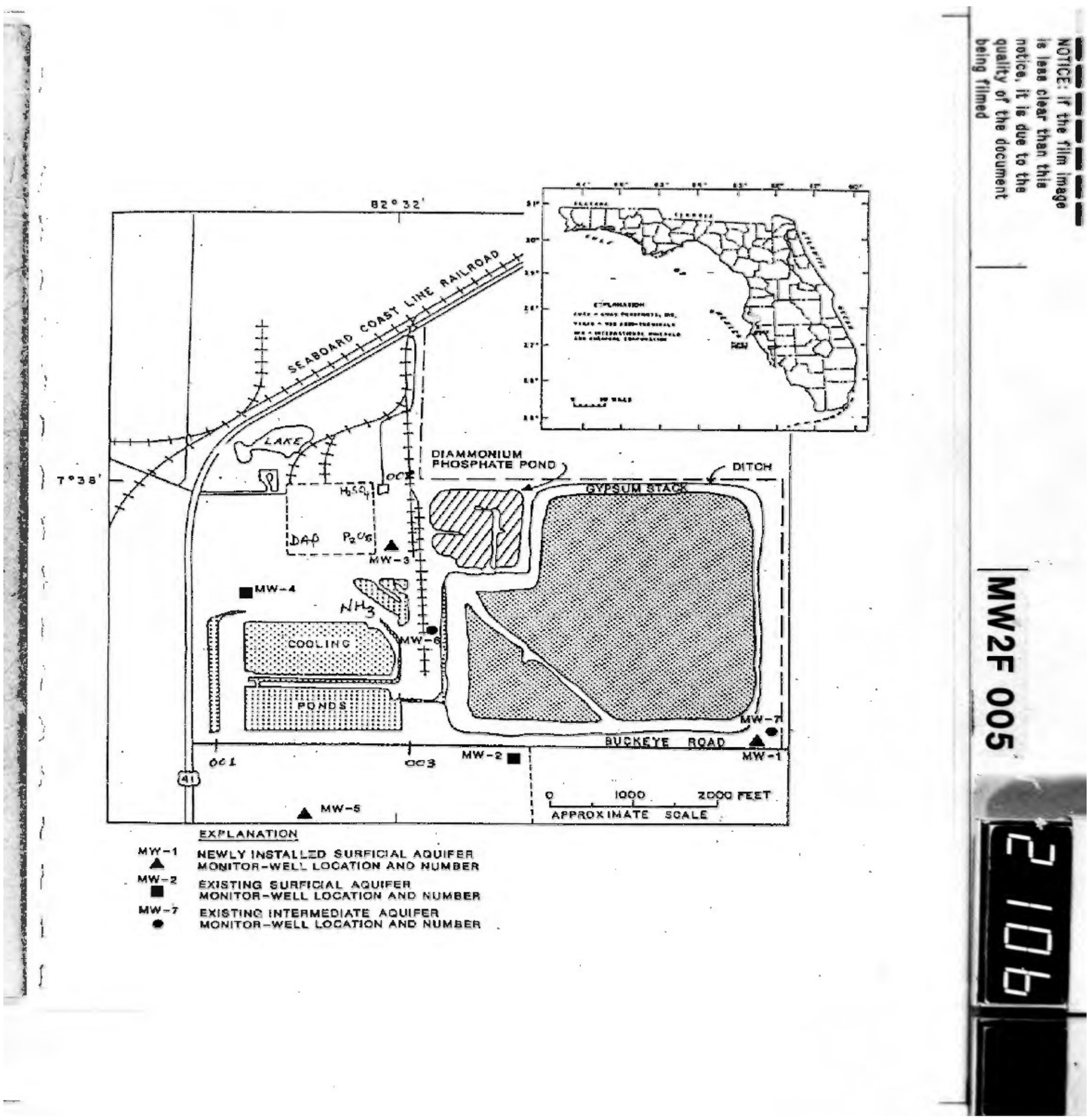
Phosphogypsum is radioactive and can contain uranium, thorium, and radium. Over time, uranium and thorium decay into radium, and radium subsequently decays further into radioactive radon, the second-leading cause of lung cancer in the United States. Radium-226, found in phosphogypsum, has a 1,600-year radioactive decay half-life. In addition to high concentrations of radioactive materials, phosphogypsum and associated process wastewater can contain carcinogens and heavy toxic metals like antimony, arsenic, barium, cadmium, chromium, copper, fluoride, lead, mercury, nickel, silver, sulfur, thallium and zinc.

A. The Piney Point facility generated and stored monoammonium and/or diammonium phosphate.

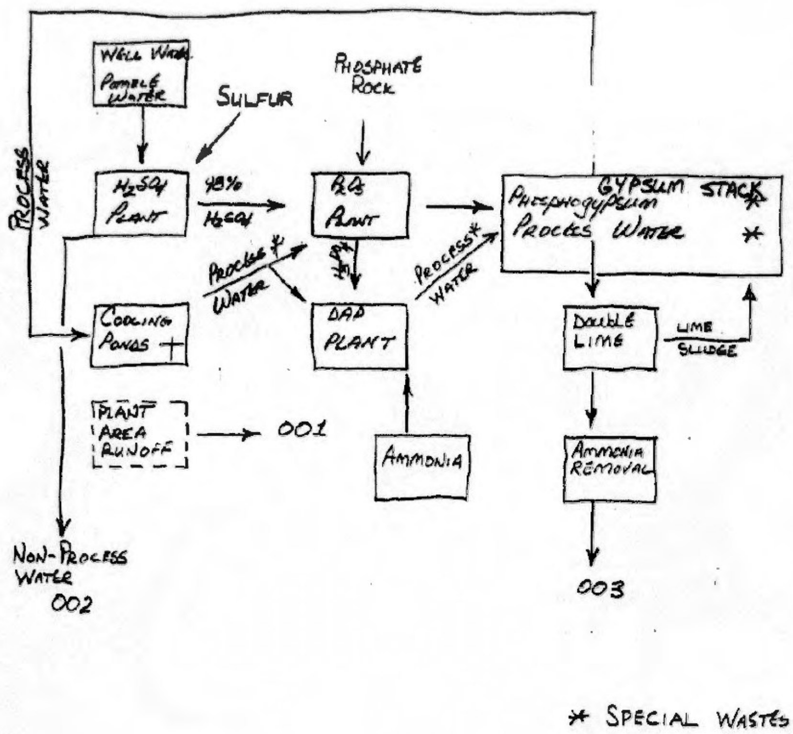
Operations at Piney Point documented the utilization of a monoammonium and/or diammonium phosphate production process in the creation of phosphate fertilizer. In 1990, Royster Phosphates, Inc., then-operator of the Piney Point facility, provided the United States Environmental Protection Agency with its response to a regulatory questionnaire entitled

"National Survey of Solid Wastes from Mineral Processing Facilities." The questionnaire was "designed to obtain information on the generation and management of selected solid wastes from mineral processing facilities." The questionnaire was EPA's method of fulfilling the Congressional requirement that EPA determine whether "Special Wastes" such as phosphogypsum should be subject to the requirements of Subtitle C of the Resource Conservation and Recovery Act (RCRA), the chapter of RCRA that focuses on hazardous wastes.

Royster Phosphates, Inc.'s response to EPA's questionnaire included maps of the Piney Point facility that demonstrate the facility utilized a monoammonium (MAP) and/or diammonium phosphate (DAP) production process. The maps identify both a DAP plant as well a "diammonium phosphate pond" at the site and show that the waste stream from the DAP production process was disposed of in the phosphogypsum stack system.



Piney Point injection well UIC Permit No. 0322708-002-UC/11, WACS Facility ID: 101607



The waste disposed of in the phosphogypsum stacks at Piney Point is hazardous waste from the Piney Point injection well UIC Permit No. 0322708-002-UC/11, WACS Facility ID: 101607

monoammonium and/or diammonium phosphate production process.[1] In fact, the United States of America recently settled two lawsuits brought under RCRA through federal consent decrees brought against fertilizer manufacturers J.R. Simplot Company and Mosaic Fertilizer LLC. In those lawsuits, the United States of America alleged that defendants unlawfully disposed of hazardous wastes from monoammonium and/or diammonium phosphate production processes into phosphogypsum stacks, and that wastes generated from monoammonium and/or diammonium phosphate production processes are not within the scope of the Bevill amendment under 40 C.F.R. § 261.4(b)(7) & (b)(7)(ii)(D).[2]

Phosphate fertilizer production at Piney Point continued until 1999. In 2001, Piney Point Phosphates, Inc., a wholly-owned subsidiary of Mulberry Corporation, operated the Piney Point site. In February 2001, Mulberry Corporation filed for bankruptcy and provided Florida State officials with 48 hours' notice that it was abandoning the property.

The property's ownership and operation then passed to the Florida Department of Environmental Protection (FDEP) through a court-ordered receivership, also in February 2001. FDEP determined that the facility needed to be closed.

At the time, Piney Point was equipped with a limestone or lime treatment facility which helps remove fluoride and phosphate, followed by ammonia via aeration, achieving over 97% removal of ammonia. While the necessary discharge rate of one million gallons a day (there was 1.2 billion gallons of process wastewater in storage at that time) was too much to safely discharge into Bishop Harbor,[3] if coupled with denitrification and releasing lower levels of water in the summer, wastewater at Piney Point could have addressed. But FDEP failed to act quickly enough and Tropical Storm Gabrielle forced the receiver into "emergency response" mode instead of "closure" mode.

In that emergency situation, FDEP and the receiver turned to reverse osmosis (RO). RO treated 350 million gallons of process water at Piney Point, which were later discharged into Tampa Bay. It was determined that the benefits of RO treatment as compared to other technologies are:

- Timeliness in installation, start-up, and water production.
- Modular equipment that enables flexibility to expand or add unit operation(s).
- High-quality RO effluent can be discharged and thus reduce the threat of an unplanned or uncontrolled release.
- Concentrate that remains results in smaller volume to "double lime" treat for final solution.

It was planned that following the complete lining of the ponds, the remaining water would be treated and disposed using RO and lime treatment, but that never happened.

[1] *See* 40 C.F.R. Part 261.
[2] *See U.S. v. J.R. Simplot Company & Simplot Phosphates, LLC*, Case No. 2:20-cv-00125-NDF, Dkt. No. 10 (D. Wyo. 2020) (Consent Decree); *U.S. v. Mosaic Fertilizer, LLC*, Case No. 2:15-cv-04889, Dkt. No. 2-1 (E.D. La. 2015) (Consent Decree).
[3] Perpich, B. et al. 2005. Mobile Wastewater Treatment Helps Remediate Concentrated Acidic Process Water at Fertilizer Plant. Florida Water Resources Journal.

B. FDEP approved the use of Piney Point for harbor dredge storage.

In 2005 the Manatee County Port Authority (MPCA) began exploring plans to create a deepwater berth for large shipping vessels and to reduce congestion in Port Manatee. The project was expected to produce 1,170,000 cubic yards of dredged material. Additional annual maintenance dredging was anticipated to produce 300,000 cubic yards of dredged material. Overall, MPCA determined it needed a disposal area sufficient to handle 3,220,000 cubic yards of material over a twenty-year maintenance period.

MPCA developed a plan to pump the dredged materials from the Port expansion into Piney Point's HDPE-lined impoundments on top of the phosphogypsum stacks. FDEP approved the permit necessary for MPCA to begin the dredging process in Environmental Resource Permit No. 0129291-0090-EM. FDEP was the real property owner of the site until August 2006 when HRK Holdings LLC (HRK) purchased Piney Point in connection with the Mulberry Corporation's bankruptcy proceeding. Shortly thereafter MPCA began negotiations with HRK and entered into a "Dredged Materials Containment Agreement" (DMCA) with HRK on April 19, 2007. FDEP and HRK entered into the First Amendment to the Administrative Agreement (hereinafter "Amended Agreement") on August 20, 2007. The Amended Agreement stated that, since HRK's purchase of Piney Point, FDEP "has continued to conduct [c]losure work and related tasks at the Site[.]" FDEP represented that "storage of dredged materials" to be generated by MPCA would be "compatible with the design and purpose of the lined reservoirs constructed by the Department[,]" and would "be of benefit to the Department."

FDEP stipulated in the Amended Agreement to not place a protective soil cover over the three impoundments to be initially used for dredged material storage: the OGS-N, OGS-S, and NGS-S (defined as the "lined DMCA Reservoir Compartments"). These impoundments would instead be used for the storage of dredged material from MPCA. FDEP specifically retained the right to "freely utilize" the NGS-N "for storage and management of process water[.]"

In August 2008, the Army Corps of Engineers (Corps) issued its "Draft Phase IIII General Revaluation Report and Environmental Assessment Addendum" (Report) on the proposal. That Report explicitly warned FDEP and MPCA not to use the Piney Point site for disposal of dredged materials from the Port Manatee expansion, stating:

> The Corps of Engineers would need to perform analyses to determine if the disposal facility meets the design and construction criteria established in Corps of Engineers guidance such as EM 1110-2-5027 and others as appropriate. In the case of the Piney Point site, there is a heightened level of concern with regard to the integrity of the gypsum stack which forms the foundation of the dredged material handling facility. The heightened level of concern follows from the following considerations:
>
> • The gypsum stack itself is not an engineered structure. There are no design plans and specifications, nor as built drawings, nor construction documentation to support the assertion of structural integrity of the stack for the purpose of supporting a material handling facility to be constructed on top of the stack.

> • The gypsum stack itself contains hazardous and toxic material.
>
> • There is documentation of past slope stability and piping issues experienced at the site.
>
> The local sponsor, the site owner, and the State of Florida Department of Environmental Protection (DEP) have supplied data and have asserted that the site is approved for the use intended. However, the Corps of Engineers has found the data to be inconclusive.

The Corps described that "the worst case scenario for Piney Point being used as dredged material disposal facility would be a breach in the liner. Such a breach would allow water to saturate and cause a failure to the gypsum stack, enabling the mixing of large volumes of dredged material with large volumes of phosphogypsum." Not only would this have dire environmental consequences, but it would also nullify the phosphogypsum stacks' legal exemption from the definition of hazardous waste under RCRA and make the dredged spoils subject to RCRA as both a solid waste and a hazardous waste. As the Corps described:

> Water from rain and the placement of dredged slurry could percolate into [the] phosphogypsum stack releasing a leachate that could be corrosive and toxic. If leachate meets the characteristics according to 40 CFR 261.22 and 40 CFR 261.24, then the leachate would be designated as hazardous waste. Then the mixture of a solid waste, with hazardous waste is considered a hazardous waste. The addition of dredged material to a hazardous waste will increase the probability of contaminating the surrounding surface and groundwater.

The Corps required FDEP to certify "Piney Point as a Dredged Material Disposal Site," to provide adequate documentation of the arrangements for use of Piney Point to store the dredged materials, and for extensive testing to ensure "that there is no hazardous material that will enter the site." It is unclear whether that ever happened.

The Corps also asked FDEP to prepare a risk assessment of potential failure modes, and for FDEP to evaluate the probability or likelihood of such failure modes. Despite having prior knowledge that the Piney Point gypsum stacks were already at risk of failure due to settling of the gypsum stacks and foundational soils, FDEP wrote to the Corps on April 8, 2010, explaining its support of the proposed use of the Piney Point phosphogypsum stacks for storage and disposal of the dredged material from the Port Manatee berth expansion. Two days later, the Corps responded, noting that Engineer Regulation 1165-2-132, "Hazardous Toxic Radioactive Waste for Civil Works Projects," specifically directed that construction in such areas should be avoided where practicable, reaffirming its position that the use of Piney Point for disposal carries unnecessary risks to the public and the environment.

FDEP continued to ignore the Corps' warnings, and as a result, the Corps requested, and FDEP provided, a formal covenant not to sue relative to the use of the closed Piney Point phosphogypsum stacks for storage and disposal of dredged material. The Corps also required

assurances from FDEP that the Corps would not be considered a potentially responsible party for purposes of environmental clean-up in the event of a leak or discharge at Piney Point.

C. Tears in Piney Point's HDPE liners lead to mixing of hazardous waste and phosphogypsum stack failures.

In February 2011, as Piney Point was being prepared for the dredging and disposal operations, a crane collapsed and punctured the HDPE liner in NGS-S. Ardaman drained NGS-S and visually inspected the floor of the liner. Approximately 150 feet from the location where the crane impacted the liner, Ardaman discovered a 6-inch breach in the liner along an extruded ballast trench seam. Beneath the liner breach, there was a "solution cavity" four feet in diameter and at least four feet deep. FDEP eventually approved all the remaining necessary state permits for MPCA to begin the dredging project, and dredging began on April 22, 2011.

Just weeks later, as the dredging process was continuing and wastes were being disposed of at Piney Point, HRK reported to FDEP increased flows, conductivity, and chloride concentrations in the buried drains based on monitoring that was required specifically for the approved dredge disposal operations at the site. On May 29, 2011, FDEP issued an Emergency Final Order (EFO No. 11-0813) that ordered HRK to take actions to help prevent the collapse of the phosphogypsum stack system and its impoundments, and authorized controlled emergency discharges as needed to protect the integrity of the stack system or its impoundments and protect waters of the state.

On June 4, 2011, FDEP directed that dredging operations be fully suspended due to continued changes in site conditions. Specifically, decreasing water levels in the NGS-S indicated a leak of at least 12,000 gallons per minute. On June 6, 2011, a strong vortex was identified near the water's edge in the southwest corner of NGS-S, similar to what FDEP's contractor, Ardaman, identified and disclosed to FDEP nearly a decade prior in the NGS-N in the 2001 Geotechnical Study. Attempts to repair the liner hole were unsuccessful and the flow rate increased to 35,000 gallons per minute. This created another vortex by the toe of the slope of the impoundment, threatening catastrophic failure.

On June 7, 2011, FDEP required HRK to perform a controlled breach to NGS-S to relieve stack pressures onsite, and to prevent an uncontrolled loss of containment from the stack system to offsite property. Emergency discharges were performed by HRK as required by FDEP in its Emergency Final Order until June 16, 2011.

All told, 169 million gallons of wastewater, consisting of dredged seawater mixed with process wastewater were discharged. Following this event, FDEP and Ardaman inspected the liner at NGS-S and identified 29 stress cracks in the liner. In October 2011, an additional five stress cracks in the liner of NGS-S were identified.

HRK completed grouting and repair operations to the phosphogypsum stack system and its impoundments by July 19, 2011, and the dredging project was allowed to resume and was completed on October 21, 2011. HRK filed for bankruptcy on June 27, 2012, after the Port Manatee expansion and dredging project was complete. Beginning in August 2012, HRK

transferred 72-107 MG of process water from NGS-N to NGS-S, followed by subsequent smaller transfers. HRK emerged from bankruptcy March 20, 2017.

D. The 2021 Piney Point discharge polluted Tampa Bay and fueled a red tide bloom.

On or about March 13, 2020, an engineering firm hired by HRK warned FDEP of serious problems with the integrity of the site and its HDPE liner. The firm explained that the risk of an uncontrolled release or breach from the site was elevated due to the deteriorating liner conditions above the water line, compromised conditions below the water line, and voids in the dikes that hold the water at the NGS-S impoundment.

On or about March 25, 2021, HRK reported to FDEP increased flow and conductivity measurements in the drains that surround the phosphogypsum impoundments. HRK's report indicated that over a 24-hour period, flow in the buried seepage interceptor drains increased over 30 gpm without any associated rainfall. Additionally, HRK reported that conductivity measurements from the drain system had gone up from previous readings of up to 6,800 umhos/cm to readings of up to 9,960. FDEP concluded that the NGS-S compartment had a leak below the water level in the impoundment.

On March 26, FDEP determined that the increased flow in the drains showed that leakage emanating from the NGS-S lined compartment was being intercepted by the buried silica-gravel drain system that surrounds the system to protect against outward migration of seepage that would otherwise impact site groundwater and discharges from Piney Point into Piney Point Creek began. FDEP later reported that a "boil," or an upwelling of water, had been observed along the east wall of the NGS-S, and HRK placed an earthen berm to provide initial containment within the stormwater ditch, through which contamination was seeping.

Despite continuous pumping, multiple boils, openings and associated releases continued and FDEP authorized the discharge of up to 480 million gallons into Tampa Bay. The governor issued a state of emergency and voluntary evacuation order for Manatee County, which turned into a three-county state of emergency and mandatory evacuation order due to worsening conditions at the site. By April 5, FDEP had taken emergency efforts to address the uncontrolled flooding from the northern toe of the NGS-N. Both siphons were discharging 24,000 gallons/minute from the NGS-N directly into Port Manatee. These discharges would continue unabated for days, releasing over 215 million gallons of untreated wastewater into Tampa Bay. The resulting discharges of nutrient-laden wastewater from Piney Point into Tampa Bay contributed to a massive red tide blooms (*Karenia brevis*).

FDEP sampling shows algae was detected in 12 water samples taken in Tampa Bay from April 8-14, 2021 in response to the Piney Point wastewater discharge, according to an FDEP blue-green algae report. Some samples have also contained trace levels of cyanotoxins. On May 26, 2021, aquaculture was closed in the area due to red tide concerns. On June 3, 2021, Hillsborough County issued a health advisory for the area near Piney Point due to red tide blooms detected in the area. During the week of June 9, 2021, red tide was detected in bloom concentrations of

greater than 100,000 cells/liter in Pinellas, Manatee, and Hillsborough counties, and fish kills suspected to be related to red tide were reported in the same counties. In June 2021, a *Lyngbya* bloom was identified in Anna Maria Sound and in Upper Sarasota Bay. *Lyngbya* is a cyanobacteria that can cause skin irritation and potentially lethal if ingested, even indirectly by eating fish that have fed on *Lyngbya*. More than 1,800 tons of dead marine wildlife have been collected in Tampa Bay, and sea turtles and dozens of manatees have died as a result of red tide.

II. Manatee County Injection Well System Permit Application

In April 2021, Manatee County applied for a permit for a Class I industrial injection well for disposal of non-hazardous industrial wastewater from the Piney Point Facility's phosphogypsum stacks and phreatic water collected by the underdrain system.[4] Manatee County also requested to convert an existing exploratory well into a monitoring well for the Class I injection well system.[5] The injection well is proposed to inject wastes from Piney Point into the Lower Floridan Aquifer with casing to a depth of 1,950 feet and an open hole from 1,950 feet to 3,300 feet.[6] The applicant speculates that the injection zone is "confined from the Upper Floridan aquifer by a thick confining bed."[7] The permit application admits that Manatee County does not know the precise geologic strata in the location where the well is planned to be installed. Instead, Manatee County asserts that the "anticipated geologic strata" were identified based on a well installed five miles away from the planned well site. The permit application further admits that Manatee County does not know the precise location where the Underground Source of Drinking Water begins or ends.

Furthermore, the applicant states that a pre-treatment facility will be "designed concurrently with permitting and construction phase of the wells," and that the specific pre-treatment strategy has not yet been determined,[8] but in any event will only assure the avoidance or limitation of the potential for plugging of the formation.[9] It states that there will be no pretreatment for any other purpose, including to treat hazardous waste:[10]

> The source water will undergo pre-treatment to adjust the water chemistry to assure compatibility… The pre-treatment facility has not been constructed and will be designed concurrently with permitting and construction phase of the well. The pre-treatment strategy is not to reduce constituents to any regulatory standard as the water has been characterized as non-hazardous and is acceptable for Class I injection. Rather, the treatment will be to assure chemical compatibility with the injection zone to avoid or limit the potential for plugging of the formation to the

[4] ASRUS, L.L.C & Jacobs, Florida Department of Environmental Protection Class I, Injection Well Construction and Testing Permit Application, Manatee County Piney Point Injection Well Part II, submitted by Manatee County, at 2-1 (April 2021).
[5] *Id.*
[6] *Id.*
[7] *Id.*
[8] *Id.*
[9] *Id.*
[10] Application at 2-1 (emphasis added).

degree possible. The type and level of treatment is yet to be determined and will be the scope of Jacobs Engineering.

The application does not clarify who deemed the waste non-hazardous or when, but FDEP Secretary Shawn Hamilton recently confirmed at a House Environment, Agriculture and Flooding Subcommittee hearing that the waste from Piney Point will not be pretreated for any other purpose than to ensure the integrity of the well.[11] This is despite the fact that water quality sampling information included with the permit application from April 9, 2019 and August 22, 2019 shows that the wastewater proposed to be disposed of in the underground injection well contains hazardous levels of pollutants, including heavy metals and radioactive waste. Notably, no sampling of the phreatic water or other wastes stored at Piney Point were provided with the permit application.

III. Florida's Ban on Hazardous Waste in Injection Wells

Florida banned hazardous waste landfills, including injection wells, when the Florida Legislature passed the Water Quality Assurance Act in 1983.[12] Floridians had significant concerns about the safety of Florida's drinking water that stemmed from the widespread use of pesticides in Florida's agricultural regions, the lack of information regarding the cumulative effects of the large number septic tanks in use throughout Florida, and a heavy reliance on groundwater for drinking water and irrigation.[13]

The statute explains that the prohibition was necessary because of Florida's high water table and soil permeability.[14] The Final Report from the Task Force explained that Florida was ill-suited for hazardous waste landfills due to its 1,000+ miles of coastline and vulnerability to saltwater intrusion.[15] It also found that Florida is highly vulnerable to groundwater contamination due to its thin soil cover, high water table, highly porous and channelized limestone formation, and high and uneven rainfall.[16] The Task Force concluded that disposal of hazardous waste by underground injection was not environmentally sound due to Florida's hydrogeological conditions.[17]

Furthermore, in 1985, Florida's administrative agency established a general prohibition of Class I wells from injecting hazardous waste which defines hazardous waste by reference to 40 § C.F.R. 261.[18] That regulation, in turn, identifies and describes hazardous waste under RCRA.

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[11] Sept. 22, 2021, at minute 43 https://thefloridachannel.org/videos/9-22-21-house-environment-agriculture-and-flooding-subcommittee/.
[12] Fla. Stat. § 403.7222 (2020).
[13] Patricia E. Norris et al., *Water Quality Policy in Three Southern States: A Comparison and Analysis of Institutional Design*, Southern Rural Development Center, at 20 (1994); Wade L. Hopping & William D. Preston, *The Water Quality Assurance Act of 1983 – Florida's "Great Leap Forward" into Groundwater Protection and Hazardous Waste Management*, 11 Fla. St. U. L. Rev. 599, 602 (1983).
[14] Fla. Stat. § 403.7222(b) (2020); *Assault on Water Bill*, St. Petersburg Times, April 18, 1983; Robert Barnes, *Legislature Wins Praise for Water Protection*, St. Petersburg Times, July 3, 1983.
[15] H.R. Rep., Report of the Speaker's Task Force on Water Issues, at 8-12 (1983).
[16] *Id.* at 118.
[17] *Id.* at 9.
[18] Fla. Admin. Code R. 17-28.20 (1985); Fla. Admin. Code R. 62-528.400 (2020).

Congress passed RCRA in 1976 to address the problems associated with industrial and municipal waste.[19] RCRA's purpose is to ensure that human health and the environment were protected from solid waste.[20] RCRA aims to regulate hazardous wastes which are discarded wastes that due to the quantity, concentration, or characteristics

> cause or significantly contribute to an increase in mortality or serious irreversible, or incapacitating reversible illness, or pose a substantial present or potential hazard to human health or the environmental when improperly treated, stored, transported, or disposed of, or otherwise managed.[21]

Because of the potential hazard for human health or the environment, phosphogypsum process wastewater were originally considered a hazardous substance for purposes of RCRA hazardous waste regulations. Phosphate rock is mined and processed to make fertilizer by exposing it to an acidic solution.[22] The acidic solution, after dissolving the rock, is considered waste and it generally contains uranium, thorium, and radium.[23] The most concerning constituents of the waste for human health are arsenic, chromium, selenium, cadmium, radium-226, lead, vanadium, copper, antimony, thallium, and fluoride.[24] Of those, arsenic, lead, cadmium, chromium, antimony, thallium, and copper are listed in EPA's Appendix VIII of 40 C.F.R § 261 list of hazardous constituents.[25] Thus, in addition to being radioactive and extremely corrosive, several of the constituents in phosphogypsum process water are hazardous.

Unfortunately, the 1980 Bevill Amendment paved the way for phosphogypsum and process wastewater associated with phosphate mining to ultimately be excluded from regulation under RCRA.[26] Specifically, in 1991, the EPA made a determination that due to costs to the industries to comply with Subtitle C of RCRA, phosphogypsum and the process waste water would be excluded from regulation.[27] Therefore, even though phosphogypsum and process water are hazardous to human health and the environment, they are not regulated by the EPA as hazardous waste due to a regulatory loophole.

IV. Piney Point Process Wastewater and Gypstacks are Hazardous Waste

Florida law prohibits the use of a Class I underground injection well for the disposal of hazardous waste.[28] However, the wastes proposed for disposal through the underground injection

[19] 42 U.S.C. § 6901(b) (202).
[20] *Id.* at § 6902.
[21] *Id.* at § 6903(5).
[22] Environmental Protection Agency, Radioactive Material From Fertilizer Production, https://www.epa.gov/radtown/radioactive-material-fertilizer-production#about-radioactive-material-from-fertilizer-production.
[23] *Id.*
[24] Environmental Protection Agency, *Report to Congress on Special Wastes from Mineral Processing: Summary and Findings Methods and Analyses Appendices*, at 12-1 (1990).
[25] *Id.* at 12-8.
[26] Environmental Protection Agency, *Final Regulatory Determination for Special Wastes from Mineral Processing (Mining Waste Exclusion)*, Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300 (June 13, 1991).
[27] *Id.*
[28] F.A.C. 62-528.400(1) (prohibiting the injection of hazardous waste through any well or septic system "except for those Class 1 wells permitted to inject hazardous waste as of January 1, 1992"). Florida expressly adopted federal

are hazardous waste.[29] Phosphogypsum stacks and associated process wastewater are exempt from regulation under RCRA as hazardous wastes by operation of the "Bevill Amendment," but *not* from regulation as solid wastes.[30] Moreover, documentation from former operators at Piney Point show the facility utilized a MAP and/or DAP production process, meaning the waste stream at Piney Point was never within the scope of the Bevill amendment, and therefore subject to regulation as hazardous waste under RCRA Subchapter C. The process water currently in several of Piney Point's gypstacks contain ammonia as nitrogen and nitrate/nitrite as nitrogen.[31] Phosphogypsum process water at Piney Point, given that it has been mixed with ammonia and nitrates, is a hazardous under the Bevill Mixture Rule.[32] Because monoammonium and/or diammonium phosphate production processes are not within the scope of the hazardous waste exclusion under 40 C.F.R. § 261.4(b)(7), the wastes proposed to be disposed of by Manatee County through the underground injection well are properly classified as hazardous waste – waste that is *prohibited* from being disposed of through underground injection.

Furthermore, as FDEP was warned by the Corps over a decade ago, the use of Piney Point for the storage of dredged materials has caused leachate to intermix with the process wastewater and phosphogypsum stacks. Specifically, the Corps warned that:

> Water from rain and the placement of dredged slurry could percolate into the phosphogypsum stack releasing leachate that could be corrosive and toxic. If leachate meets the characteristics according to 40 CFR 261.22 and 40 CFR 261.24, then the leachate would be designated as hazardous waste. Then the mixture of a solid waste, with hazardous waste is considered a hazardous waste. The addition of dredged material to a hazardous waste will increase the probability of contaminating the surrounding surface and groundwater.

The Corps' fear has become reality. Multiple liner tears have caused dredged material to leach through the liner and mix with the existing solid waste, creating a new waste material that satisfies the regulatory requirements for categorization as hazardous waste.

Federal law defines hazardous waste as any solid waste that is on lists of hazardous wastes and any other waste having a hazardous characteristic.[33] These characteristics are corrosivity, ignitability, reactivity, and toxicity.[34] The wastewater at Piney Point, which the applicant states will undergo no pretreatment for hazardous constituents, appears to be acidic and contain arsenic

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definitions and exclusions for solid and hazardous waste. F.A.C. 62-730-30(1) (adopting by reference the provisions of 40 C.F.R. Part 261).

[29] This argument is also detailed in the enclosed notices of intent to sue and amended complaint.

[30] *See, e.g.,* 40 C.F.R. § 261.4(b)(7) (preceding title: "Solid wastes which are not hazardous wastes.") & § 261.4(b)(7)(ii)(D).

[31] Environmental Protection Agency, Memorandum: Final Analytical Report at 5-11 (April 16, 2021); Environmental Protection Agency, Memo: Final Analytical Report, at 7, 11, 13 (April 19, 2021).

[32] 40 C.F.R. § 261.3(a)(2)(i), (g)(4) (2020); Consent Decree, U.S. & Florida Department of Environmental Protection v. Mosaic Fertilizer, L.L.C., at 23 (M.D. Fla 2015), available as document at https://www.epa.gov/enforcement/mosaic-fertilizer-llc-settlement.

[33] 40 C.F.R. § 261.3(a)(2)(i).

[34] 40 C.F.R.§ 261.20-262.24.

(25-100 mg/L), barium, cadmium (up to 18 mg/L), chromium (up to 16 mg/L), chloride, iron, nitrogen, ammonia, lead, magnesium, nickel, phosphorous, total gross alpha, selenium (over 4 mg/L) and many other constituents of concern.[35] More concerning, the sampling information provided to Manatee County and included in the permit application are not representative of the entirety of the waste stored at Piney Point. Therefore, regardless of whether the waste at Piney Point enjoys Bevill exemption from RCRA regulation or not, the waste poses "a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."[36]

V. Injection Wells Risks

The Floridan Aquifer is relatively well-studied in south Florida, particularly in Broward County and Miami-Dade County, but is not as well researched in Manatee County.[37] In fact, there are only two Class I well in Manatee County: one is inactive the other accepts treated wastewater.[38] Several reports describe the geologic and hydrogeologic frameworks of the Floridan Aquifer, however "these studies differ in their respective delineations" and provide inconsistent results.[39] The Floridan Aquifer is heterogenous meaning that it is not uniform throughout the entire aquifer system.[40]

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[35] Arsenic (5 mg/L), lead (5 mg/L), selenium (1 mg/L), cadmium (1 mg/L), chromium (5 mg/L) are on EPA's list of hazardous waste due to toxicity characteristic 40 C.F.R. § 261.24.

[36] *Id.* at § 6903(5).

[37] Kevin J. Cunningham, *Integration of Seismic-Reflection and Well Data to Assess the Potential Impact of Stratigraphic and Structural Features on Sustainable Water Supply from the Floridan Aquifer System, Broward County, Florida*, U.S. Geological Survey Open-File Report 2014–1136 (2014); Kevin J. Cunningham, *Seismic-Sequence Stratigraphy and Geologic Structure of the Floridan Aquifer System Near "Boulder Zone" Deep Wells in Miami-Dade County, Florida*, U.S. Geological Survey Scientific Investigations Report 2015-5013 (2015).

[38] Gao, J. 2010. Collection and analyses of physical data for deep injection wells in Florida. A Thesis Submitted to the Faculty of The College of Computer Science and Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Science. http://fau.digital.flvc.org/islandora/object/fau%3A3548/datastream/OBJ/view/Collection_and_analyses_of_physical_data_for_deep_injection_wells_in_Florida.pdf.

[39] *Id.*; James A. Miller, *Hydrogeologic framework of the Floridan aquifer system in Florida, and in parts of Georgia, Alabama, and South Carolina*, U.S. Geological Survey Professional Paper 1403–B, 91 (1986).; Frederick W. Meyer, *Hydrogeology, ground-water movement, and subsurface storage in the Floridan aquifer system in southern Florida*, U.S. Geological Survey Professional Paper 1403–G, 59 (1989); Ronald S. Reese & Kevin J. Cunningham, *Hydrogeologic Framework and Salinity Distribution of the Floridan Aquifer System of Broward County, Florida*, U.S. Geological Survey Scientific Investigations Report 2014–5029, 60 (2014); Ronald S. Reese & Emily Richardson, *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida*, U.S. Geological Survey Scientific Investigations Report 2007–5207, 60 (2008); Kevin J. Cunningham, *Seismic-sequence Stratigraphy and Geologic Structure of the Floridan Aquifer System Near "Boulder Zone" Deep Wells in Miami-Dade County, Florida*, U.S. Geological Survey Scientific Investigations Report 2015–5013, 28 (2015); Lester J. Williams & Eve L. Kuniansky, *Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina*, U.S. Geological Survey Professional Paper 1807, 140 (2015); Kevin J. Cunningham, *et al.*, *Three-dimensional Seismic Characterization of Karst in the Floridan Aquifer System, Southeastern Miami-Dade County, Florida*, U.S. Geological Survey Scientific Investigations Report 2018–5177, 39 (2018).

[40] A. B. Tihansky, Effects of Aquifer Heterogeneity on Ground-Water Flow and Chloride Concentrations in the Upper Floridan Aquifer near and within an Active Pumping Well Field, West-Center Florida, U.S. Geological Survey Scientific Investigations Report 2004-5268, 2 (2004).

The contours of the Lower Floridan aquifer are not as well studied or known as the Upper Floridan aquifer, but much of it contains saltwater.[41] One study from 2019 attempted to clarify the geological and hydrogeological framework of the Lower Floridan Aquifer at a wastewater treatment plant in Miami-Dade County.[42] The study was needed because monitor zones above the injection zone for a wastewater treatment plant's Class I injection well system detected ammonia.[43] The single-well and multi-well aquifer packer tests aimed at describing the hydraulic characteristics of the aquifer were "inconsistent and largely qualitative."[44] Thus, the status of the confinement between the Boulder Zone and the top of the Lower Floridan Aquifer was inconclusive.[45] The monitor wells used to complete multi-well aquifer tests showed poor confinement, but the single well aquifer tests showed effective confinement.[46] The study addressed this contradiction by explaining that the two tests assess different volumes and part of a heterogenous and anisotropic aquifer.[47] The study looked at geological and geophysical data to *conceptually* understand the porosity and permeability of the system.[48] Another study on this issue found monitoring wells recorded ammonia concentrations above ambient levels 1,000 feet above injection depths.[49]

Manatee County included a Well System Diagram that shows IW-1 having casing until 1,950 feet, then an open hole until around 3,300 feet where the hole meets backfilled cement. The Diagram shows that the casing would be installed about 50 feet after the bottom of the Middle Confining Unit II and indicates that the underground sources of drinking water are protected from contamination by the well via the Middle Confining Unit II. While one landscape-scale study cited in the application suggests that aspects of the Middle Confining Unit II is a "non-leaky confining unit" and that this unit has poor connection with the freshwater in the overlying Upper Floridan Aquifer, the Diagram fails to show that the Middle Confining Unit II is not uniform throughout all of Florida. In West-central Florida, the Middle Confining Unit II is suspected to be non-leaky but East-central Florida (Orange County) and South Florida (Palm Beach County) do not have the same confining unit. Instead, this region has a non-evaporate bearing, semi-confining unit. Even if the underwater source of drinking water can be protected by the Middle Confining Unit II at the well site, this does not mean that that the underground sources of drinking water in other areas of the state are protected from the injection substances.

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[41] https://pubs.usgs.gov/ha/ha730/ch_g/G-text6.html Ground Water Atlas of the United States Alabama, Florida, Georgia, South Carolina HA 730-G.

[42] Kevin L. DeFosset, *Hydrogeologic Characterization of Part of the Lower Floridan Aquifer at the South District Wastewater Treatment Plant, Miami-Dade, Florida*, U.S. Geological Survey Report 2019-1034, 1 (2019).

[43] *Id.*

[44] *Id.* at 13.

[45] *Id.*

[46] *Id.*

[47] *Id.* Anisotropic means "having a physical property that has a different value when measured in different directions. A simple example is wood, which is stronger along the grain than across it."

[48] *Id.*

[49] Sepulveda, N. and M. Lohmann. 2021. Migration of Injected Wastewater with High Levels of Ammonia in a Saline Aquifer in South Florida. Ground Water 59(4): 597-613.

Beneath the Middle Confining Unit II in West-central Florida is the Lower Avon Park permeable zone, the glauconite marker unit, and the Oldsmar permeable zone.[50] Beneath the non-evaporate semi-confining unit of East-central Florida (Orange County) and South Florida (Palm Beach County), there are also those same zones.[51] Based on several different diagrams, the Lower Avon Park permeable zone, glauconite marker unit, and Oldsmar permeable zone are connected throughout the entire state of Florida from the west to the east coasts.[52]

A study by Ardaman in 2019 for the Florida Industrial and Phosphate Research Institute, a legislatively-created industry think-tank, used geochemical modeling to perform leaching tests for process wastewater.[53] The purpose of the study was "to investigate use of deep injection wells for disposal of treated process water and contaminated non-process water" "instead of treating the water to best available technology" to "result in significant savings in treatment costs". The study found that process wastewater with lime treatment plus filtration of process water had the most favorable results, but that wastewater, including wastewater from Piney Point which served as a sample for the modeling, had unacceptable levels of leaching without treatment. It found that:

> Lime-treatment of process waters is necessary to avoid significant reduction in horizontal hydraulic conductivity ovpinellaser time in the injection zone of a deep injection well due to the precipitation of minerals within the rock formation. This reduction in horizontal hydraulic conductivity could ultimately lead to failure of the deep injection well.

Process water treated to a pH of 8.0 to precipitate fluoride and phosphorous and other constituents using a lime slurry showed a more favorable potential for using deepwell injection. Process water run through only a 0.45-micron filter, including wastewater from Piney Point (Source #7A), showed less favorable potential for using a deep injection well, and that the wastewater from Piney Point had relatively high phosphorous concentrations. The model was run through core samples from southwest Florida, southeast Florida and the Atlantic coast, but not from the Tampa Bay region.

A study of all Class 1 injection wells in Florida found that depth below the drinking water source was the most significant factor to prevent upward migration of the injected fluid.[54] It found that in the southwest district (Pinellas, Manatee, Polk, and Sarasota counties) 36% of Class 1 wells were leaking.[55]

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[50] *Id.* at 83.
[51] *Id.* at 18
[52] *Id.*
[53] Ardaman. 2019. Leaching study for select process and non-process waters relative to future disposal through a deep injection well.
[54] Gao, J. 2010. Collection and analyses of physical data for deep injection wells in Florida. A Thesis Submitted to the Faculty of The College of Computer Science and Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Science. http://fau.digital.flvc.org/islandora/object/fau%3A3548/datastream/OBJ/view/Collection_and_analyses_of_physical_data_for_deep_injection_wells_in_Florida.pdf.
[55] *Id.*

Another study comparing southeast Florida and Pinellas County found that the risk to human health from fluid movement into drinking water was higher in Pinellas County than other study areas because the shallower aquifer depth and lack of confinement.[56] It noted that the risk would be even higher but for the fact that effluent is subject to high levels of disinfection.

Rising seas and saltwater intrusion also pose an uncertainty with potential for change in Florida's aquifer system. Global average sea level rose by seven to eight inches over the past century as the oceans have warmed and land-based ice has melted. Sea level rise is accelerating in pace with almost half of recorded sea level rise occurring since 1993. The Fourth National Climate Assessment estimated that global sea level is very likely to rise by 0.3 to 0.6 feet by 2030, 0.5 to 1.2 feet by 2050, and 1.0 to 4.0 feet by the end of the century relative to the year 2000, with sea level rise in excess of 8 feet possible.[57] The impacts of sea level rise will be long-lived: under all scenarios, sea levels will continue to rise for many centuries.[58]

Unfortunately, the sea level rise projected for Florida reflects the global outlook, with sea level rise projections of between 2 and 6 feet within this century. The Southeast Florida Regional Climate Change Compact counties released a 2019 update to their "Unified Sea Level Rise Projection" for south Florida with projections for south Florida sea-level rise in excess of the expected global average: 0.6 to 1.0 feet by 2030; 1.1 to 1.9 feet by 2050; and 2.7 to 6.1 feet by 2100. These projections are considered most likely, but less conservative estimates indicate that sea level rise could go as high as 1.2, 2.5, and 8.6 feet in 2030, 2050, and 2100, respectively.[59] It is unclear how this would impact the Floridan aquifer system and this well in particular.

In sum, there is very little site-specific research about the geology and potential impacts of injecting hazardous waste at the location of the proposed underground injection well, including its possible contamination of underground drinking water resources. Most of the research that exists for the Lower Floridan Aquifer is conceptual and based on studies treating municipal

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[56] EPA. Relative Risk Assessment of Management Options for Treated Wastewater in South Florida. https://www.nrc.gov/docs/ML1710/ML17103A460.pdf.

[57] Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner. 2018. Our Changing Climate. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144. doi: 10.7930/NCA4.2018.CH2.

[58] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT; U.S. Global Change Research Program (USGCRP). 2017. Climate Science Special Report: Fourth National Climate Assessment, Vol. I. Available at: https://science2017.globalchange.gov/.

[59] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group. 2019. Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee. 36 p. Available at http://southeastfloridaclimatecompact.org/.

waste not hazardous waste. Given the added uncertainties of sea-level rise, it is there are too many unknowns to proceed safely.

VI. Conclusion

The waste at Piney Point is hazardous, whether Bevill-exempt or not. It is inappropriate and unlawful to inject that waste in a Class 1 well without significant pretreatment. Moreover, the uncertainty of deepwell injection in this area makes Piney Point a poor testcase. Much of the data necessary to determine if the well can be compliant with state regulations will not come until *after* FDEP has issued the permit and the well has been bored. Given FDEP's track record at Piney Point, the required monitoring well and financial assurances do not cure this uncertainty. FDEP did precious little while Piney Point's monitoring wells for 20 years detected waste from the stack polluting groundwater while various companies took possession and moved through bankruptcy and FDEP waived financial assurances.

Deepwell injection of Piney point waste should be abandoned as too risky. Manatee County's efforts should be invested in proven treatment technologies that have already been piloted at Piney Point, such that future storage and/or disposal of Piney Point's waste is no longer needed.

Please do not hesitate to contact us at 727-490-9190 or jlopez@biologicaldiversity.org with any questions or concerns about these comments.

Please send each of the undersigned organizations notice of FDEP's intent to issue the permit and any other correspondence regarding this permit application at the email addresses provided below.

Thank you,

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The response of Tampa Bay to a legacy mining nutrient release in the year following the event

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Introduction: Cultural eutrophication threatens numerous ecological and economical resources of Florida's coastal ecosystems, such as beaches, mangroves, and seagrasses. In April 2021, an infrastructure failure at the retired Piney Point phosphorus mining retention reservoir garnered national attention, as 814 million liters of nutrient rich water were released into Tampa Bay, Florida over 10 days. The release of nitrogen and phosphorus-rich water into Tampa Bay – a region that had been known as a restoration success story since the 1990s – has highlighted the potential for unexpected challenges for coastal nutrient management.

Methods: For a year after the release, we sampled bi-weekly at four sites to monitor changes in nutrients, stable isotopes, and phytoplankton communities, complemented with continuous monitoring by multiparameter sondes. Our data complement the synthesis efforts of regional partners, the Tampa Bay and Sarasota Bay Estuary Programs, to better understand the effects of anthropogenic nutrients on estuarine health.

Results: Phytoplankton community structure indicated an initial diatom bloom that dissipated by the end of April 2021. In the summer, the bay was dominated by *Karenia brevis*, with conditions improving into the fall. To determine if there was a unique carbon (C) and nitrogen (N) signature of the discharge water, stable isotope values of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) were analyzed in suspended particulate material (SPM). The $\delta^{15}N$ values of the discharge SPM were –17.88‰ ± 0.76, which is exceptionally low and was unique relative to other nutrient sources in the region. In May and early June of 2021, all sites exhibited a decline in the $\delta^{15}N$ values of SPM, suggesting that discharged N was incorporated into SPM after the event. The occurrence of very low $\delta^{15}N$ values at the reference site, on the Gulf Coast outside of the Bay, indicates that some of the discharge was transported outside of Tampa Bay.

Discussion: This work illustrates the need for comprehensive nutrient management strategies to assess and manage the full range of consequences associated with anthropogenic nutrient inputs into coastal ecosystems. Ongoing and anticipated impacts of climate change – such as increasing tropical storm intensity, temperatures, rainfall, and sea level rise – will exacerbate this need.

KEYWORDS
phosphogypsum, stable isotopes, phytoplankton, harmful algal bloom, carbon, nitrogen, Piney Point

1. Introduction

Cultural eutrophication and climate change are two of the most important threats to the health and sustainability of coastal ecosystems around the world (Nixon, 1995; Hoegh-Guldberg and Bruno, 2010; Doney et al., 2012). From an algal perspective, cultural eutrophication has elevated the potential for harmful algal blooms (HABs; Cloern, 2001; Paerl et al., 2006; Heisler et al., 2008; Glibert, 2020; Gobler, 2020). Current trends in climatic conditions are exacerbating the challenges associated with eutrophication due to increases in temperature, changes in rainfall patterns, and increases in the intensity of tropical storms (Webster et al., 2005; Oneil et al., 2012; Wetz and Yoskowitz, 2013; Glibert et al., 2014; Griffith and Gobler, 2020; Phlips et al., 2020). One of the potential mechanisms for the combined impacts of eutrophication and climate change is the disruption of engineered structures associated with water treatment and retention (Lehner et al., 2011; Beusen et al., 2015; Grill et al., 2015; Maavara et al., 2015). Accidental or unavoidable discharges from compromised infrastructure can expose surrounding aquatic environments to excessive nutrient, algal and pollutant loads that negatively affect water quality, including elevated risks for HABs (Sin et al., 2013; Phlips et al., 2020; Herren et al., 2021; Metcalf et al., 2021). In this study, we examined an emergency release of water from a retired phosphorus mining reservoir into Tampa Bay, Florida and evaluated changes in water quality and algal populations in the Bay a year after the event.

Tampa Bay was designated as an impaired coastal waterbody in the 1980s, in part because of widespread losses of seagrasses. Subsequent restoration efforts and targeted nutrient management strategies resulted in successful restoration of seagrass habitats by the end of the century (Yates et al., 2011; Greening et al., 2014; Sherwood et al., 2017; Tomasko et al., 2018; Beck et al., 2019; DeAngelis et al., 2020; Tomasko et al., 2020). Despite these successes, nutrient management is an ongoing challenge due to increased development, reclaimed water usage, and septic and industrial activities adjacent to the Bay. Recently, higher shallow water temperatures and relatively high, sustained hydrologic inputs potentially linked to climate change drivers may also be confounding nutrient management efforts (Tampa Bay Nitrogen Management Consortium (TBNMC), 2022). During the 2016–2022 period, significant seagrass coverage was lost according to aerial photography estimates (>25% decline from 2016 peak coverage, or > 11,000 acres of seagrass coverage loss; SWFWMD, unpublished data). In addition to this recent bay-wide and regional seagrass loss, water quality declines in the northern portion of the bay (Old Tampa Bay) have occurred, and unexpected events, such as periodic releases of industrial process water, have caused further management challenges (Tampa Bay Estuary Program, 2022).

In late March 2021, an impaired liner at a decommissioned fertilizer facility (Piney Point) prompted the emergency release of 814 million liters of process water mixed with dredge water into the Bay, from March 30th to April 9th, 2021 (Nelson et al., 2021; Beck et al., 2022). The discharge water was high in inorganic nutrients, specifically ammonium and orthophosphate, prompting concerns that this pulse of nutrients might result in increased primary productivity, including phytoplankton, macroalgae and HABs, with adverse effects to seagrass meadows and other coastal habitats. Initial analyses soon after the event determined that there was a localized diatom bloom, and that the excess nutrients within the bay may have exacerbated the development of a red tide (*Karenia brevis*) bloom that was transported into the Bay (Beck et al., 2022).

While the initial effects of the discharge have been reported, the long-term effects on water quality and phytoplankton community structure have not yet been investigated. Here, we further investigate the fate of nutrients released from Piney Point and characterize the water quality conditions and phytoplankton community composition for the year following the event. We hypothesized that the initial pulse of inorganic nutrients was readily utilized by phytoplankton communities. This likely led to internal cycling of Piney Point-derived nutrients within the Bay, although other mechanisms, such as the deposition of nutrients into bay sediments and transport of nutrients outside of the bay were also likely important mechanisms influencing the fate of nutrients discharged from the facility. To evaluate this hypothesis, we monitored changes in water column nutrients, *in situ* water quality parameters, stable isotopes of carbon (C) and nitrogen (N) in suspended particulate material (SPM), chlorophyll *a* concentrations, and phytoplankton community structure over the course of a year after the event.

Our year-long monitoring campaign confirmed there was an initial diatom bloom adjacent to the location of the discharge that dissipated by the end of April 2021, as previously described in Beck et al. (2022), and revealed that elevated diatom biomass was more extensive than previously recognized as it extended to back bay regions. During the summer, the site adjacent to Piney Point had high *K. brevis* biomass (3 mg C L^{-1}), which then declined into the fall. We found that the stable isotope values of C and N ($\delta^{13}C$ and $\delta^{15}N$) of the discharge water SPM were-15.23‰ ± 0.53 and-17.88‰ ± 0.76, respectively. A $\delta^{15}N$ value of-17.88‰ is exceptionally low and was unique relative to other nutrient sources in the region, likely due to isotopic fractionation associated with ammonium assimilation within the reservoir. In May and early June of 2021, all sites in the discharge region exhibited a sharp decline in the $\delta^{15}N$ values of SPM, suggesting that discharge N was incorporated into SPM after the event, which may have been driven either by phytoplankton uptake of N and/or N sorption onto particulate material in the bay. This was further supported by concomitant declines in C:N values. After mid-June 2021, $\delta^{15}N$ values generally returned to April 2021 values. This study found that phytoplankton communities and water quality were altered by the Piney Point event and that these dynamics can be influenced by tropical storms, highlighting the synergistic effects between disruptions of engineered structures and periodic events such as storms, which are predicted to increase in intensity due to climate change (Webster et al., 2005; Wetz and Yoskowitz, 2013).

2. Methods

2.1. Site description

Four sites were selected in consultation with the Tampa Bay Estuary Program (TBEP) and the University of South Florida's Tampa Bay Coastal Ocean model (Chen et al., 2018, 2019). The sites included: one site proximal to Piney Point Creek, which is connected to the Piney Point facility *via* drainage canals (hereafter referred to as Piney Point), two back bay regions that were located south of the discharge location and forecast to have longer residence times (Bishop Harbor and Joe Bay), and one reference site outside of the Bay (St. Joseph Sound; Figure 1). All sites were located adjacent to TBEP seagrass monitoring transects (Beck et al., 2022) and had depths that varied with the tidal cycle, but generally ranged from 1–3 m. One of the back

bay regions (Bishop Harbor) was the site of previous releases from the Piney Point facility (Garrett et al., 2011; Switzer et al., 2011), and the reference site was outside of the Bay, at a relatively pristine location with healthy seagrass meadows (Tomasko et al., 2020). For this event, emergency releases were conveyed directly into Tampa Bay in the vicinity of Port Manatee from March 30th to April 9th 2021, while an uncontrolled discharge to Piney Point creek occurred from March 30th to April 3rd, 2021 (Florida Department of Environmental Protection, 2021; Figure 1).

Water samples were collected on a bi-weekly basis from April 2021 until April 2022. At each site, water samples were collected from surface to near bottom (to avoid collection of bottom material) on a near bi-weekly basis using a depth-integrated pole sampling method (Phlips et al., 2010) to minimize any bias from water column stratification. Water samples were collected for total and dissolved nutrients, suspended particulate material (SPM), chlorophyll *a*, and phytoplankton community analyses, as described below. In addition to bi-weekly water samples, a discharge water sample was collected on April 7th, 2021, and processed as described for other water samples.

FIGURE 1
(A) Location of the Piney Point facility and study sites within and outside Tampa Bay. **(B)** Lower bay sites and their location in relationship to Piney Point and the discharge locations. Discharges occurred at Port Manatee from March 31st to April 9th, and at Piney Point Creek until April 3rd. Sites are marked with yellow points, locations of interest are marked with red points.

An additional sample collection was conducted in October 2021 at the southern holding pond where the initial liner tear occurred to evaluate seasonal changes in reservoir characteristics and efforts to employ innovative treatment technologies within the remaining wastewater held at the facility following the emergency release. All samples were transported on ice and either refrigerated or frozen until analyzed.

2.2. Chlorophyll *a* and phytoplankton analyses

Water samples were collected and filtered for chlorophyll *a* analysis in the field. Phytoplankton were filtered onto 0.7-µm Whatman glass fiber filter and stored in a dark container at −20°C. Chlorophyll *a* was solvent extracted (Sartory and Grobbelaar, 1984) and measured spectrophotometrically according to Standard Methods (American Public Health Association, 2005).

Integrated, whole water samples were preserved on-site with Lugol's solution (American Public Health Association, 2005) and analyzed microscopically for phytoplankton abundance and species composition. General phytoplankton abundance and composition were determined using the Utermöhl method (Utermohl, 1958), as described in Badylak et al. (2014). Samples preserved in Lugol's were settled in 19 mm diameter cylindrical chambers. Phytoplankton cells were identified and counted at 400× and 100× with a Leica phase contrast inverted microscope. At 400×, a minimum of 100 cells of a single taxon and 5 grids were counted. If 100 cells were not counted by 30 grids, up to a maximum of 100 grids were counted until 100 cells of a single taxon were reached. At 100×, a total bottom count was completed for taxa >30 µm in size.

Picocyanobacteria abundances were determined using a Zeiss Axio compound microscope, using green and blue light excitation (Fahnenstiel and Carrick, 1992; Phlips et al., 1999). Samples were preserved with buffered glutaraldehyde. Subsamples of water were filtered onto 0.2 µm Nucleopore filters and mounted between a microscope slide and cover slip with immersion oil and picoplankton counted at 1000x magnification.

Count data were converted to phytoplankton biovolume, using the closest geometric shape method (Smayda, 1978; Sun and Liu, 2003). Phytoplankton C values (as mg C L^{-1}) were estimated by applying conversion factors for different taxonomic groups to biovolume estimates (expressed as $10^6 \mu m^3 mL^{-1}$): i.e., 0.065 × biovolume of diatoms, 0.22 x biovolume for cyanobacteria, and 0.16 × biovolume for dinoflagellates or other taxa (Strathmann, 1967; Ahlgren, 1983; Sicko-Goad et al., 1984; Verity et al., 1992; Work et al., 2005).

2.3. *In situ* measurements

A YSI EXO2 multiparameter sonde was deployed at each of the four study sites on April 16th, 2021, soon after the discharge ceased on April 9th. Deployment depth ranged from 1–3 m, depending on the site. Sondes continuously measured salinity, optical dissolved oxygen (DO), *in situ* chlorophyll, phycoerythrin (PE), fluorescent dissolved organic matter (fDOM), specific conductivity, temperature, pH, total dissolved solids, turbidity, and total suspended solids every 10 min. The average value for each day is reported here. Sondes were

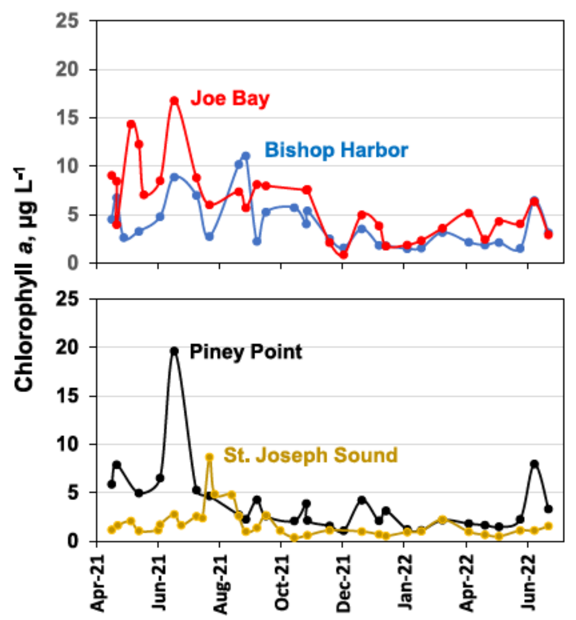

FIGURE 2
Chlorophyll *a* concentrations (µgL^{-1}) at the three lower bay sampling sites (i.e., Bishop Harbor, Joe Bay, and Piney Point), and reference site (i.e., St. Joseph Sound).

inspected on a bi-weekly basis, with maintenance and calibration occurring every ~3 weeks, or sooner if needed, according to the manufacturer's instructions. Data were downloaded from sondes during bi-weekly sampling trips using KorEXO software. Data from April 16th, 2021 to May 5th, 2022 were aggregated and cleaned for this study using R version 4.1 (R Core Development Team, 2008). Values that were out of sensor range were flagged and removed from the dataset prior to analysis. For all parameters, approximately 1% or less of the values were out of range, except for *in situ* chlorophyll where 9.8% of the values were out of range.

2.4. Dissolved and particulate samples

Water samples collected for total phosphorus (TP) and total Kjeldahl nitrogen (TKN) were acidified to a pH of 2 in the field prior to analysis and analyzed within 28 days according to EPA Method 365.1 and 353.2, respectively. Water samples for ammonium-N (NH_4-N) and nitrate + nitrite (NO_x) analyses were 0.2 µm filtered and acidified to a pH of 2 in the field and analyzed within 28 days according to EPA Method 350.1. Water samples for total orthophosphate (orthoP) were not acidified and were analyzed within 48 h according to EPA Method 365.1. All nutrient analyses were certified and conducted at the University of Florida's Analytical Research Laboratory, a National Environmental Laboratory Accreditation Program (NELAP) certified facility. Values below the minimum detection limit were set to NA prior to analysis.

Suspended particulate material was collected on pre-combusted, pre-weighed glass fiber filters (GF/F), frozen and then freeze dried. Filters were then placed into tin capsules for elemental (total carbon (TC) and total nitrogen (TN)) and stable isotope ($\delta^{13}C$, $\delta^{15}N$) analysis. Elemental and stable isotope analyses were conducted at the University of Florida's Stable Isotope Laboratory, using a Carlo Erba 1500 CN elemental analyzer coupled to a Thermo Electron DeltaV Advantage isotope ratio mass spectrometer (Carlo Erba/ThermoFisher Scientific™, Waltham, MA, United States). Stable isotope ratios are reported for $\delta^{13}C$ and $\delta^{15}N$ in standard delta notation (‰) relative to Vienna Pee Dee Belemnite (VPDB) and atmospheric N_2 standards, respectively. Total carbon and TN are reported on a percent mass basis. The C:N ratio is reported as the mass ratio, i.e., weight %TC ÷ weight %TN.

2.5. Data analysis

Data analysis was conducted in R version 4.1 (R Core Development Team, 2008). Grab sample values (i.e., chlorophyll *a*, phytoplankton, elemental analysis and isotope values) were averaged by location and month, while *in situ* sonde measurements were averaged by location and day. Trends in these values were then examined to elucidate the timing of maximum and minimum values relative to the emergency release and Tropical Storm Elsa, as well as variation between sites and relative to published values. Analysis scripts are available at the following GitHub repository.[1]

3. Results

3.1. Chlorophyll *a* concentrations and total phytoplankton biomass

Chlorophyll *a* concentrations were used as one of the indicators of phytoplankton biomass. Overall temporal trends in chlorophyll *a* concentrations were similar at the three lower bay sampling sites, with concentrations mostly over 5 µg L^{-1} from April through August 2021 (Figure 2), exceeding an annual average lower bay management target of 4.6 µg L^{-1} (Tampa Bay Estuary Program, 2022). Peaks in chlorophyll *a* during the latter period of April–August reached values up to 20 µg L^{-1} at Piney Point. After summer, chlorophyll *a* declined to below 5 µg L^{-1} through the end of the study period, with a few exceptions. By contrast, chlorophyll *a* concentrations at the St. Joseph Sound reference site were consistently below 3 µg L^{-1} except for moderately elevated concentrations in July and August of 2021, coincident to red tide blooms that extended along the Southwest Florida coast during this time. Lower Tampa Bay values exceeded the 2006 to 2020 long-term median chlorophyll *a* value of lower Tampa Bay, which was 3.1 µg L^{-1} (min 2.3 µg L^{-1}, max 3.5 µg L^{-1}; Beck et al., 2022), but values of the reference site were similar to the long-term median value of the Lower Tampa Bay (3.1 µg L^{-1}).

On April 7th, 2021, emergency release water was dominated by a spherical single-celled green alga (Chlorophyta). Cell density of the green alga was 3.4 × 10^8 cells L^{-1}, and biomass was 2.34 mg C L^{-1}, almost an order of magnitude higher than the mean biomass for the study period in the Piney Point nearshore basin which was 0.36 mg C L^{-1}. The discharge sample also contained several other species of

1 https://github.com/elisemorrison/PineyPoint2021

nanophytoplankton, but the biomass contributions of these taxa were minor, i.e., < 0.02 mg C L^{-1}.

The time-series of total phytoplankton biomass for the three lower bay sampling sites (i.e., Piney Point, Bishop Harbor, and Joe Bay) from April 9th, 2021, through May 2022 exhibited similar temporal patterns, with elevated levels in the late Spring of 2021, with peaks near, or over, 1.5 mg C L^{-1} (Figure 3). In mid-summer, biomass levels declined, and remained near, or below, 0.5 mg C L^{-1} through the end of the study period in May 2022. The reference site in St. Joseph Sound had modestly elevated total biomass in June and July, with peaks near 0.5 mg C L^{-1}, then remained below 0.3 mg C L^{-1} for the rest of the study period. Mean total phytoplankton biomass values for the study period were similar across the three lower bay sampling sites, while the reference site exhibited the lowest value – although statistically it could not be differentiated from the Bishop Harbor or Piney Point sites (Table 1).

3.2. Phytoplankton composition

The initial peaks in phytoplankton biomass at the Bishop Harbor, Joe Bay and Piney Point sites in May 2021 were dominated by diatoms (Figure 3). Three diatom taxa, *Leptocylindrus minimus*, *Leptocylindrus danicus*, and *Cerataulina pelagica,* dominated the initial peak period in terms of biomass (Table 2). The subsequent major peak in biomass at the Piney Point site in June was dominated by the toxic dinoflagellate *Karenia brevis* and reached 3 mg C L^{-1}. The more modest peaks in biomass at St. Joseph Sound in May and June of 2022 were dominated by dinoflagellates, including *K. brevis* in June. After July 2022, the Bishop Harbor, Joe Bay, and Piney Point sites showed variability in dominant taxa, with periods of supremacy by all four major phytoplankton groups, i.e., dinoflagellates, diatoms, cyanobacteria (primarily picocyanobacteria), and "other" taxa (most prominently nanophytoplankton, such as cryptophytes; Figure 3; Table 2).

Over the study period, mean biomass of diatoms were higher than dinoflagellates, cyanobacteria and "other" taxa at Bishop Harbor and Joe Bay (Table 1). At Piney Point, mean dinoflagellate and diatom biomass was higher than cyanobacteria and "other" taxa. At St. Joseph Sound, there were no significant differences in mean biomass of the four phytoplankton groups. In terms of regional differences within each phytoplankton group, mean dinoflagellate and cyanobacteria biomass levels across all the sites were not significantly different, despite the high mean value of dinoflagellates at the Piney Point site (Table 1). The apparent anomalously high annual mean at Piney Point reflects the effect of exceptionally high biomass of *K. brevis* in June on the mean. Joe Bay had a significantly higher mean diatom biomass than at St. Joseph Sound. For "other" taxa, Joe Bay had the highest mean biomass and St. Joseph Sound had the lowest mean biomass.

To examine more specific differences in taxonomic composition at the reference and lower study sites, a comparison was made of the individual taxa that accounted for the top 10% of biomass observations in the two regions, which roughly represented the Top-50 taxa observations at the St. Joseph Sound (reference site), and the Top-150 taxa observations for the combined results from the Bishop Harbor, Joe Bay and Piney Point sites (lower bay sites; Table 2). There were several key similarities, including the strong representation of cyanobacteria on both lists, and many similarities in the list of dinoflagellate species, including the prominence of the HAB species *Karlodinium veneficum* and *K. brevis*. These similarities fall in line with the lack of significant differences between sites for mean values of cyanobacteria and dinoflagellates biomass over the study period (Table 1). By contrast, for diatoms, there was a wider range of species and higher biomass values for the lower bay sites than the reference site (Table 2). The Top-150 list for the lower bay sites was led by spherical picoplanktonic cyanobacteria, other undefined small nanoplanktonic eukaryotes and the euryhaline cosmopolitan diatom species *Skeletonema costatum, L. danicus* and *Rhizosolenia setigera*, in terms of frequency on the list (Table 2). In terms of highest biomass observations, the dinoflagellate *K. brevis*, and the diatoms *L. minimus*, *L. danicus*, *Guinardia delicatula, Skeletonema costatum*, and *C. pelagica* led the Top-150 list, with peak biomass values greater than 0.40 mg C L^{-1}.

The Top-50 list for the St. Joseph Sound reference site was led by spherical picoplanktonic cyanobacteria, other undefined small nanoplanktonic eukaryotes, and the dinoflagellate *Karlodinium veneficum*, in terms of frequency on the list (Table 2). for the three primary sampling sites. In terms of highest biomass observations in the Top-50 list for the St. Joseph Sound reference site, only *K. brevis* had a peak value similar to that encountered in the Top-150 list, i.e., 0.25 mg C L^{-1}.

Another feature of the Top-50 and Top-150 lists of highest biomass observations was the presence of known HAB species, most of which are potential producers of toxins (Lassus et al., 2015; Table 2). The largest number of HAB species for both lists were dinoflagellates. *K. veneficum, K. brevis*, *Takayama* sp. and *Akashiwo sanguinea* were near the top of both lists in terms of HAB species. *K. brevis* had the highest peak biomass for HAB species in both lists, with a peak of 2.71 mg C L^{-1} (i.e., 3.9 million cells L^{-1}) on the Top-150 list, which represents a major bloom. The potentially toxic filamentous nitrogen-fixing cyanobacterium *Trichodesmium erythraeum* and pennate diatom *Pseudo-nitzschia* sp. were on both lists. *Karenia brevis* was the only HAB species that reached major levels of concern in terms of harmful impact during this study period.

3.3. Total and dissolved nutrients

On April 6th, 2021, the water discharged from the facility was dominated by inorganic nutrients, namely ammonium-N (210 mg L^{-1}) and orthophosphate (140 mg L^{-1}), with NO_x concentrations of 0.004 mg L^{-1} (Supplementary Table 1; Beck et al., 2022). All sites exhibited their greatest orthoP values in April 2021, with lower orthoP concentrations seen at sites further from the discharge site at that time (Supplementary Tables 1, 2). OrthoP values were greater in April 2021 when compared to April 2022 for all sites. All sites also exhibited their highest average total P values in April 2021 and had lower TP values in April 2022 when compared to April 2021, except for the reference site St. Joseph Sound. St. Joseph Sound had slightly lower total P values in April 2021 (11.38 µg L^{-1}) when compared to April 2022 (13.71 µg L^{-1}). For all sites, ammonium-N was highest in the first 5 months after the event, and in January 2022 with concentrations peaking in June and July of 2021 and in January 2022. Average monthly ammonium-N values in the lower Tampa Bay sites were from 0.14 mg L^{-1} (Piney Point and Bishop Harbor) to 0.17 mg L^{-1} (Joe Bay). Generally, NO_x was not detectable at our sites (Supplementary Tables 1, 2).

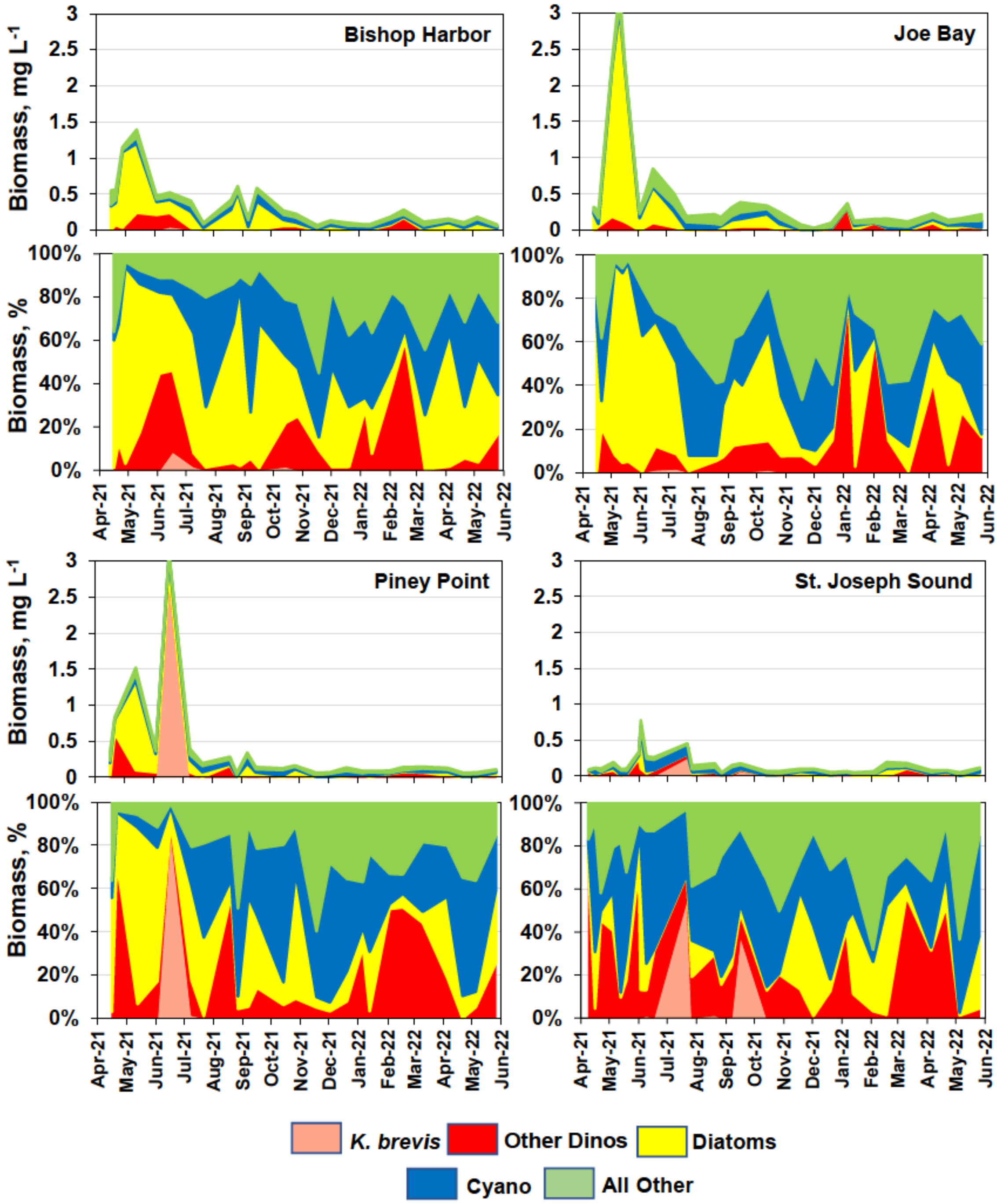

FIGURE 3
Time series of phytoplankton biomass (mg carbon L^{-1}) for the four core sites, i.e., Bishop Harbor, Joe Bay, Piney Point, and St. Joseph Sound (reference site). Time series are divided into four phytoplankton groups, dinoflagellates (red), diatoms (yellow), cyanobacteria (blue), and all "other" taxa (green). Bottom panels for each site show relative (%) contribution of each group to total biomass.

3.4. *In situ* measurements

For *in situ* measurements, there were distinct differences between the study sites. Salinity was consistently higher at the reference site, St. Joseph Sound (lowest 27.04 psu in mid-February 2022 and highest in early June 2021 34.96 psu) relative to the lower bay sites (0.66 to 34.94 psu). Salinity was highest at the beginning of the study period (Figure 4A), particularly for Piney Point and Bishop Harbor, which are further into the Bay. Joe Bay (closer to the mouth of Tampa Bay), and St. Joseph Sound (reference site) had increases in salinity through May and June 2021, then a decline in salinity in June and July 2021. Joe Bay's salinity was lowest in mid-August 2021 (24.70 psu), and greatest in mid-June 2021 (34.94 psu). Piney Point's salinity was lowest in early July 2021 (16.98 psu), likely due to Tropical storm Elsa, and greatest in early June 2021 (33.13 psu). Bishop Harbor's salinity dipped in October 2021 to 0.66 psu, and its highest salinity was at the end of May 2021 (34.47 psu; Figure 4A).

TABLE 1 Mean biomass of four groups of phytoplankton (i.e., dinoflagellates, diatoms, cyanobacteria and all "other" taxa) at the four sampling sites (i.e., Bishop Harbor, Joe Bay, Piney Point and St. Joseph Sound) over the entire study period.

Phytoplankton Group	Mean Biomass, μg carbon L^{-1}			
	Bishop Harbor	Joe Bay	Piney Point	St. Joseph Sound
Dinoflagellates	0.050 b	0.055 b	0.168 a	0.048 a
	(0.015)	*(0.014)*	*(0.113)*	*(0.013)*
	A	A	A	A
Diatoms	0.192 a	0.329 a	0.115 a	0.035 a
	(0.054)	*(0.143)*	*(0.050)*	*(0.018)*
	AB	A	AB	B
Cyanobacteria	0.050 b	0.048 b	0.044 b	0.045 a
	(0.005)	*(0.005)*	*(0.005)*	*(0.008)*
	A	A	A	A
Other Taxa	0.054 b	0.085 b	0.039 b	0.030 a
	(0.008)	*(0.010)*	*(0.005)*	*(0.003)*
	B	A	BC	C
Total	0.347	0.516	0.366	0.159
	(0.065)	(0.153)	(0.131)	(0.027)
	AB	A	AB	B

Standard errors are shown in parentheses. The results of Duncan multiple range tests are shown as letters associated with the mean values. Capital letters relate to statistical differences between mean values for a phytoplankton group at each of the four sampling sites. A comparison of mean values for total phytoplankton biomass at the four sampling sites is shown at the bottom of the Table. Lower case letters relate to differences in mean values for the four phytoplankton groups at each site. Mean values with the same letter designation are not significantly different.

Dissolved oxygen (DO) was greatest at the reference site, St. Joseph Sound, and at Piney Point, while DO was lower in the back bay sites (Figure 4B). DO values tended to be lowest in mid- to late summer of 2021 and were highest from December 2021 to February 2022. All sites exhibited a slight decline in DO into the summer, and experienced increases in DO starting in October 2021, with a peak in DO in early 2022. The lowest daily mean DO at Bishop Harbor was at the end of September 2021 (1.52 mg L^{-1}) and greatest in early February 2022 (8.98 mg L^{-1}). The lowest DO at Joe Bay was in mid-June (3.45 mg L^{-1}) and highest in December 2021 (8.63 mg L^{-1}). The lowest DO at Piney Point was at the end of June (4.64 mg L^{-1}) and greatest in early July 2021 (10.27 mg L^{-1}; Figure 4B), at the time of peak *K. brevis* blooms in the Bay. The lowest DO at the reference site St. Joseph Sound was at the end of September 2021 (4.06 mg L^{-1}) and greatest in February 2022 (9.90 mg L^{-1}).

In situ chlorophyll was consistently higher when compared to extracted chlorophyll *a* (described above), and was greatest at Joe Bay and Piney Point, both of which exhibited an increase in June and July 2021. In general, sites exhibited the greatest *in situ* chlorophyll values in mid-summer 2021, during the period of peak *K. brevis* blooms, and lowest values in the late fall and winter (Figure 4C). At Bishop Harbor, *in situ* chlorophyll was greatest in early September 2021 (24.99 μg L^{-1}), and lowest in late December 2021 (0.59 μg L^{-1}). At Joe Bay, the greatest *in situ* chlorophyll values were in late June 2021 (36.96 μg L^{-1}), and the lowest values were in early December 2021 (0.95 μg L^{-1}). At the Piney Point site, the greatest *in situ* chlorophyll was in early July 2021 (30.21 μg L^{-1}), and the lowest values were in mid-December 2021 (2.55 μg L^{-1}). At St. Joseph Sound, the greatest *in situ* chlorophyll values were in mid-July 2021 (24.4 μg L^{-1}), and the lowest values were in mid-October 2021 (0.03 μg L^{-1}).

Phycoerythrin (PE) was greatest at Piney Point and Joe Bay, which had spikes in PE in June and July of 2021 (Figure 4D). Similar to *in situ* chlorophyll, PE was greatest in mid-summer 2021, corresponding with *K. brevis* blooms in the region, and lowest in the winter months. At Bishop Harbor, PE was greatest in early September 2021 (15.55 relative fluorescent units [RFU]) and lowest in late November 2021 (0.63 RFU). At Joe Bay, PE was greatest in mid-June 2021 (15.81 RFU) and lowest in early December (0.69 RFU). At Piney Point, PE was greatest in early July (14.74 RFU) and lowest in mid-May (1.32 RFU). At St. Joseph Sound, the greatest PE values were in mid-July (9.74 RFU), and lowest values were in mid-December (0.05 RFU).

Florescent dissolved organic matter (fDOM) was consistently higher in the back bay sites Bishop Harbor and Joe Bay, and lowest in the reference site, St. Joseph Sound. All lower bay sites exhibited an increase in fDOM in late July 2021 (Supplementary Figure 1). At Bishop Harbor the lowest value was early October 2021 (10.97 quinine sulfate units [QSU]) and greatest in mid-August 2021 (54.54 QSU). Joe bay was lowest in March 2022 (0.67 QSU) and highest in late July (42.84 QSU). Piney Point was lowest in mid-April 2022 (15.11 QSU) and greatest in mid-August 2021 (55.84 QSU). St. Joseph Sound was lowest in mid-December 2021 (5.15 QSU) and greatest in mid-October 2021 (22.34 QSU).

Patterns of turbidity varied by region (Supplementary Figure 1). The turbidity at Bishop Harbor was lowest in mid-August 2021 [0.31 formazin nephelometric units (FNU)] and greatest in early September 2021 (22.71 FNU), which coincided with higher *in situ* chlorophyll and PE values. The turbidity at Joe Bay was lowest in late January 2022 (0.70 FNU) and greatest in mid-September 2021 (42.59 FNU). Piney Point had the lowest turbidity in mid-August 2021 (0.41 FNU) and greatest in late November 2021 (68.12 FNU). St. Joseph Sound had the lowest turbidity in mid-October 2021 (0.29 FNU) and greatest in mid-July 2021 (82.76 FNU).

3.5. Suspended particulate material

The discharge water SPM had an exceptionally depleted $\delta^{15}N$ value of −17.88‰ ± 0.76, and a $\delta^{13}C$ value of −15.23‰ ± 0.53. Stable isotope values were determined with a precision of 0.05‰ and 0.09‰ for $\delta^{15}N$ and $\delta^{13}C$, respectively. The total nitrogen (TN) of the discharge water SPM was 2.8% ± 0.1, and total carbon (TC) was 11.9% ± 0.5, with a C:N ratio of 4.3 ± 0.2. The SPM of the reservoir water in October had similarly low $\delta^{15}N$ and $\delta^{13}C$ values as the discharge water from April, −19.15‰ ± 0.05 and −13.44 ‰ ± 0.03, respectively. Differences between the SPM from April discharge and October reservoir samples are likely due to the fact that on-site treatment technologies were being employed at the site since April 2021.

The greatest particulate TC values (2.88–3.77%) were seen in April 2021 for three of the four sites and then declined over the course of the study period (Figure 5A). The only exception was Piney Point, which

TABLE 2 List of Top-50 individual biomass observations for individual taxa over the study period at the reference site, St. Joseph Sound (top panel), and Top-150 for the combined record for the three lower bay sites, i.e., Bishop Harbor, Joe Bay, and Piney Point (bottom panel).

Reference site – St. Joseph Sound				
		Frequency	Biomass range	Max. #Cells
Species	Group	Top-50	Carbon mg L^{-1}	10^3 cells L^{-1}
Cryptophyte spp.	Cryptophytes	3	0.02–0.03	3,537
Spherical picocyanobacteria spp.	Cyanobacteria	15	0.03–0.16	894,902
Synechococcus spp.		2	0.02–0.04	116,726
*Trichodesmium erythraeum**		1	0.05	5
Leptocylindrus danicus	Diatoms	3	0.04–0.08	362
Chaetoceros sp.		2	0.04–0.13	2,181
Amphora/Entomoneis sp.		2	0.02–0.11	907
Chaetoceros wighamii		1	0.09	15,600
Pseudo-nitzschia sp.*		1	0.04	3,265
Thalassionema bacillare		1	0.02	181
*Karlodinium veneficum**	Dinoflagellates	5	0.02–0.16	635
*Karenia brevis**		2	0.07–0.25	355
*Akashiwo sanguinea**		2	0.03–0.06	8
Takayama sp.*		1	0.06	181
Protoperidinium brevipes		1	0.06	91
Gyrodinium pingue		1	0.03	91
*Prorocentrum texanum**		1	0.03	9
*Prorocentrum minimum**		1	0.02	91
Nanoplankton spp. (2 μ–5 μ) (UD)	Nanophytoplankton	5	0.02–0.05	15,238
		Biomass range in top-50: 0.02–0.25		
Primary sites – Bishop Harbor, Joe Bay, and Piney Point				
		Frequency	Biomass range	Max. #Cells
Species	Group	Top-150	Carbon mg L^{-1}	10^3 cells L^{-1}
Cryptophyte spp.	Cryptophytes	3	0.04–0.05	5,351
Spherical picocyanobacteria	Cyanobacteria	32	0.05–0.16	894,902
*Trichodesmium erythraeum**		1	0.05	5
Rhizosolenia setigera	Diatoms	9	0.06–0.12	2,902
Skeletonema costatum		7	0.19–0.42	29,568
Leptocylindrus danicus		7	0.08–0.73	3,325
Chaetoceros sp.		5	0.05–0.06	3,627
Dactyliosolen fragilissimus		4	0.08–0.36	3,265
Cerataulina pelagica		4	0.07–0.42	2,358
Guinardia delicatula		4	0.05–0.61	1995
Leptocylindrus minimus		3	1.05–1.95	132,393
Amphora/Entomoneis sp.		3	0.06–0.11	907
Pennate diatom sp.		3	0.05–0.07	12,879
Bellerochea horologicalis		2	0.04–0.05	9
Coscinodiscus sp.		1	0.14	2
Chaetoceros wighamii		1	0.09	15,600
Cyclotella choctawhatcheana		1	0.08	28,117
Thalassionema bacillare		1	0.08	605
Chaetoceros costatus		1	0.07	726
Grammatophora marina		1	0.07	181
Rhabdonema adriaticum		1	0.07	11
Chaetoceros danicus		1	0.05	605
Pseudo-nitzschia sp.*		1	0.04	3,265

(Continued)

TABLE 2 (Continued)

Primary sites – Bishop Harbor, Joe Bay, and Piney Point				
		Frequency	Biomass range	Max. #Cells
Species	Group	Top-150	Carbon mg L^{-1}	10^3 cells L^{-1}
*Karlodinium veneficum**	Dinoflagellates	17	0.05–0.19	726
*Karenia brevis**		4	0.04–2.71	3,847
Takayama sp.*		4	0.06–0.07	302
*Karenia mikimoto**		2	0.10–0.11	181
*Prorocentrum rhathymum**		2	0.06–0.34	94
*Akashiwo sanguinea**		2	0.06–0.27	31
Gymnoid sp.		2	0.06–0.09	2,720
Peridinium quinquecorne		1	0.2	181
*Prorocentrum texanum**		1	0.1	29
Protoperidinium brevipes		1	0.06	91
Nanoplankton spp. (2 μ–5 μ) (UD)	Nanophytoplankton	18	0.05–0.20	64,088
		Biomass range in top-150: 0.04–2.72		

Frequency of occurrence on the "Top" lists for each taxon are shown, along with the range of biomass values for the observations on the list, and the highest cell density observed for taxa on the lists. Taxa* with an asterisk are species on the IOC Harmful Algal Bloom list (Lundholm et al., 2009 onwards). "UD" indicates observations without a specific species identification.

exhibited its highest TC values (2.4% ± 1.3) in June 2021 coinciding with the *K. brevis* bloom in the bay and had its second highest TC in April 2021 (average 1.8% ± 0.5; max 2.6%), concurrent with the release from the Piney Point facility. The lowest TC values at Bishop Harbor and St. Joseph Sound site were seen in mid-July 2021 (0.2 ± 0.02%). A similar trend was seen in TN values, where Bishop Harbor and Joe Bay exhibited their greatest TN values in April 2021 (0.3–0.46%) Piney Point had its greatest particulate TN value in June 2021 (0.32% ± 0.10; Figure 5B). After early July 2021, sites exhibited a decline in particulate TN, with the exception of St. Joseph Sound, which exhibited an increase in particulate TN in August 2021, followed by a decline.

Over the study period, the lower Tampa Bay sites showed similar trends in C:N values, with all sites exhibiting a higher C:N value in April 2021, with a subsequent decline in C:N to a value of ~5 in June 2021 (Figure 5C). After June 2021, C:N values of the bay sites increased and then stabilized from July 2021 to April 2022. Patterns in C:N were slightly different at the reference site, St. Joseph Sound, which also had high C:N values in April 2021, and a subsequent decrease in June 2021. However, in July 2021 there was a decline in C:N at St. Joseph Sound, likely driven by an influx of N derived from the surrounding watershed in association with Tropical Storm Elsa's passing. Values then quickly increased and plateaued, until another decline in C:N was seen in January 2022 at St. Joseph Sound. The lower Tampa Bay sites also exhibited a slight decrease in C:N at this time, but to lesser degrees.

All sites exhibited similar trends from April to December 2021 for $\delta^{15}N$ in SPM (Figure 6A). Specifically, $\delta^{15}N$ values declined in all regions in May 2021, with values as low as −11.4‰ at Bishop Harbor, and −10.8‰ ± 0.02 at Piney Point, while the lowest average values at the reference site, St. Joseph Sound (−8.75‰ ± 10.8). and Joe Bay (−4.28‰ ± 7.7), were seen in June 2021. The decline in $\delta^{15}N$ values may be related to mixing and/or uptake of N from the Piney Point discharge since the SPM $\delta^{15}N$ value of the Piney Point discharge in April 2021 was −17.88‰ ± 0.76. Additionally, the Bishop Harbor and St. Joseph Sound sites had an increase in $\delta^{15}N$ values in January 2022, which coincided with a drop in C:N values, possibly driven by terrestrial inputs of N, or remineralization by macroalgae in the region.

In April 2021, $\delta^{13}C$ values were consistently low at all sites ranging from −26.1 ± 3.3 at St. Joseph Sound to −22.6‰ ± 0.9 at Joe Bay. An increase in $\delta^{13}C$ values was seen in May 2021 (Figure 6B), possibly driven by C input from SPM within the Piney Point discharge, which had $\delta^{13}C$ values ranging from −14.01 to −15.82‰.

4. Discussion

4.1. Initial phytoplankton response to the discharge

Temporal trends in phytoplankton composition and biomass offer insights into possible effects of the 2021 Piney Point discharge event on Tampa Bay proper. Chlorophyll *a* concentrations in the 3 months following the discharge period were significantly higher than the same period in the following year at all three Bay sites proximal to the source of the discharge (i.e., Bishop Harbor, Joe Bay, and Piney Point). At the reference site, St. Joseph Sound, outside of Tampa Bay proper, there was no major elevation of chlorophyll *a* concentrations during the 3 months directly after the discharge period, followed by moderately elevated concentrations in July and August of 2021, coincident with red tide blooms that extended along the Southwest Florida coast during this time. During the 3 months following the discharge, peak chlorophyll *a* values at our Tampa Bay sites fell within a range associated with meso-eutrophic coastal regions, i.e., > 10–20 μg L^{-1} (Hagy III et al., 2022). The latter chlorophyll levels (~20 μg L^{-1}) are common in the northeast region of upper Tampa Bay, which is subject to autochthonous HAB events, including blooms of the toxic dinoflagellate *Pyrodinium bahamense*, but are rare in the outer regions of the bay (Badylak et al., 2007). As such, the chlorophyll *a* values seen in the three months following

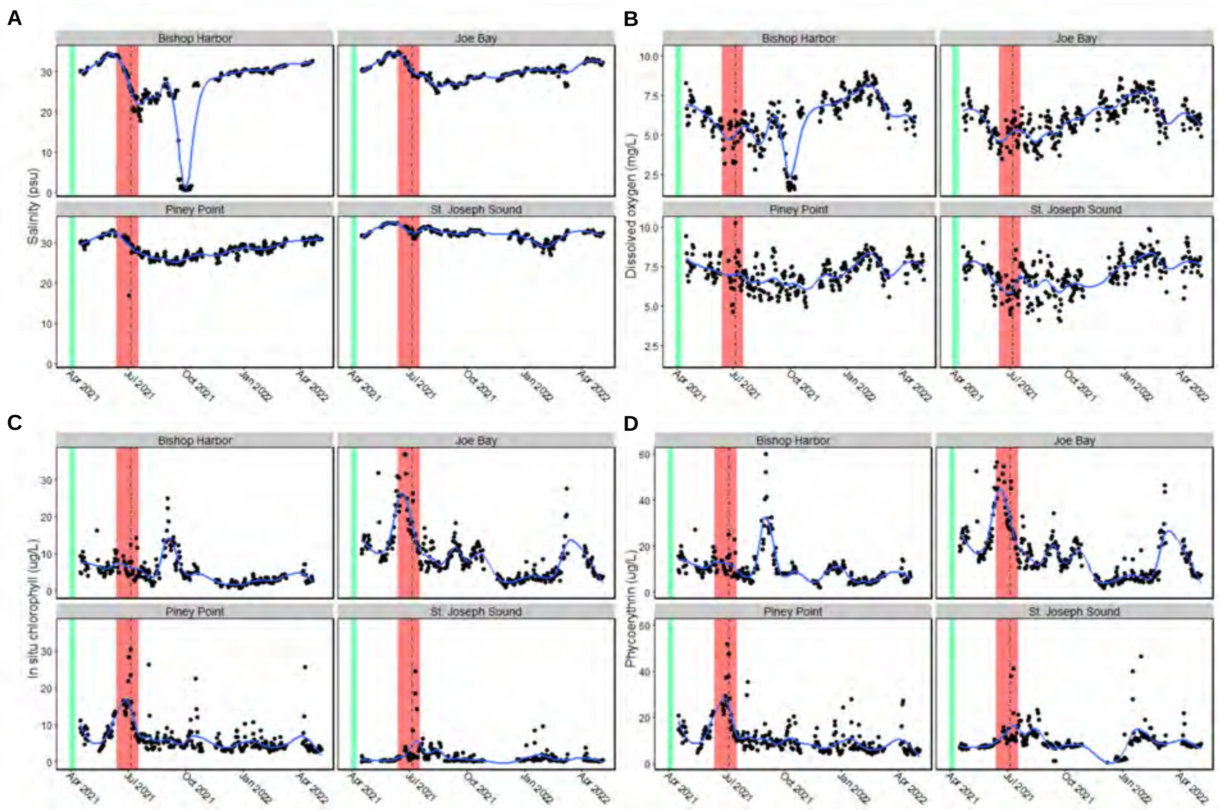

FIGURE 4
In situ measurements for daily means of **(A)** salinity (psu), **(B)** dissolved oxygen (mgL^{-1}), **(C)** *in situ* chlorophyll (μgL^{-1}), and **(D)** phycoerythrin (relative fluorescence units, RFU) over the course of the study. The Piney Point event (March 30th – April 9th, 2021) is denoted by the green line, the period with maximum (> 10^5 cells L^{-1}) *Karenia brevis* cell counts (Beck et al., 2022) is shown in the red box, and the date of tropical storm Elsa (July 5th, 2021) is shown with the vertical dashed black line. The smoothing line was generated using local polynomial regression fitting with a span of 0.175.

the discharge exceeded the long-term median and range of chlorophyll *a* values in lower Tampa Bay from 2006 to 2020, which was 3.1 μg L^{-1} and 2.3–3.5 μg L^{-1} (Beck et al., 2022), and exceeded the annual average lower bay management target of 4.6 μg L^{-1} (Tampa Bay Estuary Program, 2022). High chlorophyll *a* levels are encountered along the southwest coast of Florida during red tides of the toxic dinoflagellate *Karenia brevis* (Heil et al., 2014; Milbrandt et al., 2021; Phlips et al., 2023), which periodically intrude into Tampa Bay, as observed in this study (Beck et al., 2022).

Peaks in phytoplankton biomass observed at the lower bay sampling sites in the 2 months following the Piney Point discharge event were dominated by euryhaline diatom species (Eppley, 1977; Brand, 1984; Balzano et al., 2011; Karthik et al., 2017), most prominently *Leptocylindrus minimus*, *Leptocylindrus danicus*, and *Cerataulina pelagica*. The three species are commonly found in estuaries around the world (Reynolds, 2006), and in Florida (Badylak and Phlips, 2004; Quinlan and Phlips, 2007; Hart et al., 2015), including Tampa Bay (Badylak et al., 2007). The euryhaline characteristic of these species makes them competitive in estuaries like Tampa Bay, in which salinities can range from mesohaline (i.e., 5–18 psu) to euhaline (i.e., >30 psu), as observed in the three lower bay sites in this study. The three diatom species are also known to have high maximum growth rates, i.e., >1.5 dbl. day^{-1} (Stolte and Garcés, 2006; Ajani et al., 2016). The high growth rates allow such species to take advantage of pulses of nutrients (Litchman et al., 2007; Cermeño et al., 2011; Karthik et al., 2017; Anderson et al., 2022), such as those observed with the Piney Point discharge, compared to many bloom-forming dinoflagellates encountered in coastal ecosystems in Florida (Phlips et al., 2006, 2011) which have maximum growth rates less than 1 dbl. day^{-1} (Stolte and Garcés, 2006; Matsubara et al., 2007). This is particularly true during cooler months of the year in Florida when water temperatures fall within 20–25°C, which is well within the optimal temperature range for growth of these diatom species, as opposed to other regionally important bloom-forming cyanobacteria and dinoflagellate species which have growth temperature optima between 25 and 35°C (Phlips and Mitsui, 1982; Montagnes and Franklin, 2001; Phlips et al., 2006; Anderson and Rynearson, 2020). Another factor that can enhance the success of diatom taxa with spines, a characteristic of the three aforementioned species, is lower grazing loss rates (Irigoien et al., 2005). While most diatoms are not viewed as serious HAB species, with the noted exception of toxin-producing species of *Pseudo-nitzschia* (Lassus et al., 2015), major blooms of *Leptocylindrus* and *Cerataulina* have been implicated in mortalities, or other health issues, in fish and shellfish populations, in relationship to physical damage, production of congestive muscilage, or generation of hypoxic conditions (Taylor et al., 1985; Buschmann et al., 2006; Ianora et al., 2008; Martin and LeGresley, 2014). These observations highlight the importance of including these types of taxa in monitoring and management plans for impacted ecosystems such as Tampa Bay.

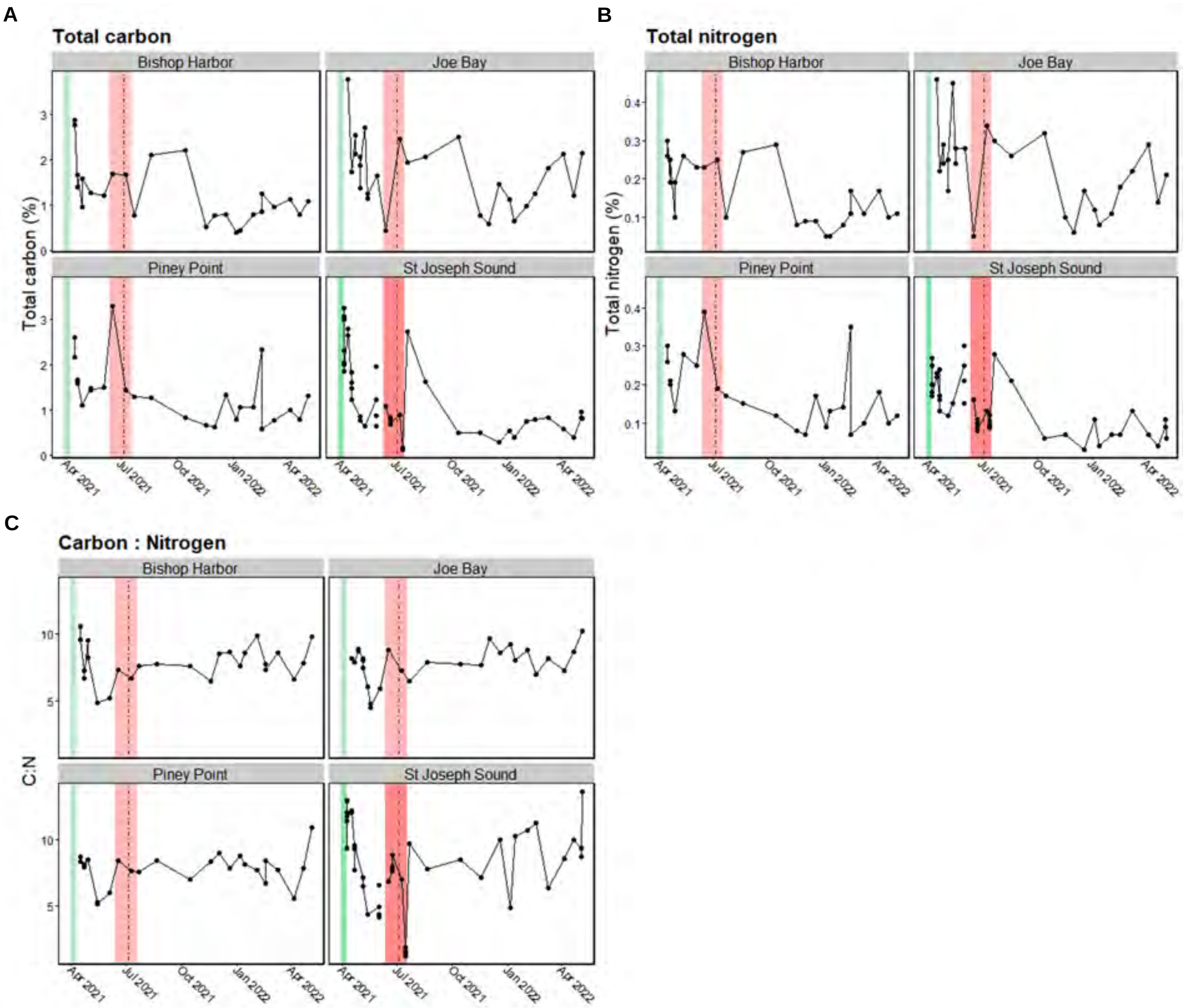

FIGURE 5
Bulk measures for suspended particulate material (SPM) for each location over the study period. Values for **(A)** total suspended particulate carbon, **(B)** total suspended particulate nitrogen, and **(C)** Carbon to Nitrogen (C:N) ratios are presented for each site. The Piney Point event (March 30th – April 9th, 2021) is denoted by the green line, the period with maximum (> 10^5 cells L^{-1}) *Karenia brevis* cell counts (Beck et al., 2022) is shown in the red box, and the date of tropical storm Elsa (July 5th, 2021) is shown with the vertical dashed black line. The smoothing line was generated using local polynomial regression fitting with a span of 0.175.

4.2. Karenia brevis *bloom dynamics post-discharge*

Another noteworthy aspect of the post Piney Point discharge period were peak biomass observations of the toxic red tide dinoflagellate, *K. brevis* at the Piney Point site in June 2021. *Karenia brevis* was also observed at Bishop Harbor and St. Joseph Sound during the same general time period, at lower biomass levels. This corroborates with Beck et al. (2022), who reported high concentrations of *K. brevis* in lower and middle Tampa Bay for the weeks of June 13th to July 18th, 2021. During the *K. brevis* bloom, there was an increase in extracted and *in situ* chlorophyll, as well as *in situ* measurements of PE. The peak biomass value for *K. brevis* observed at Piney Point was 2.71 mg C L^{-1} (i.e., 3.85 million cells L^{-1}), which ranks it as a major bloom of concern to the health of the estuary - including the potential for animal mortalities, development of anoxia, and human health issues (Kirkpatrick et al., 2004; Fleming et al., 2005; Landsberg et al., 2009; Heil and Muni-Morgan, 2021). During this period, extensive fish kills were also reported in Middle and Lower Tampa Bay (Beck et al., 2022; Florida Fish and Wildlife Conservation Commission, 2022).

K. brevis is a HAB species whose blooms initiate on the west Florida Shelf from upwelling events and are then advected to the nearshore through wind and currents, where they negatively affect coastal communities, particularly on the southwest coast of Florida between Tampa Bay and the Caloosahatchee Basin (Heil et al., 2014; Weisberg et al., 2019). The source of *K. brevis* at our study sites was likely the Gulf of Mexico, brought inshore by winds and current, and was facilitated by high salinities and available nutrients in the bay at that time, since *K. brevis* is known to be somewhat intolerant of low salinities (i.e., <20 psu; Steidinger, 2009; Beck et al., 2022). *K. brevis* blooms are a common feature along the west coast of Florida (Steidinger, 2009; Vargo, 2009; Heil et al., 2014), and typically originate offshore on the coastal shelf, and then are introduced to coastal estuaries through prevailing nearshore circulation patterns (Weisberg

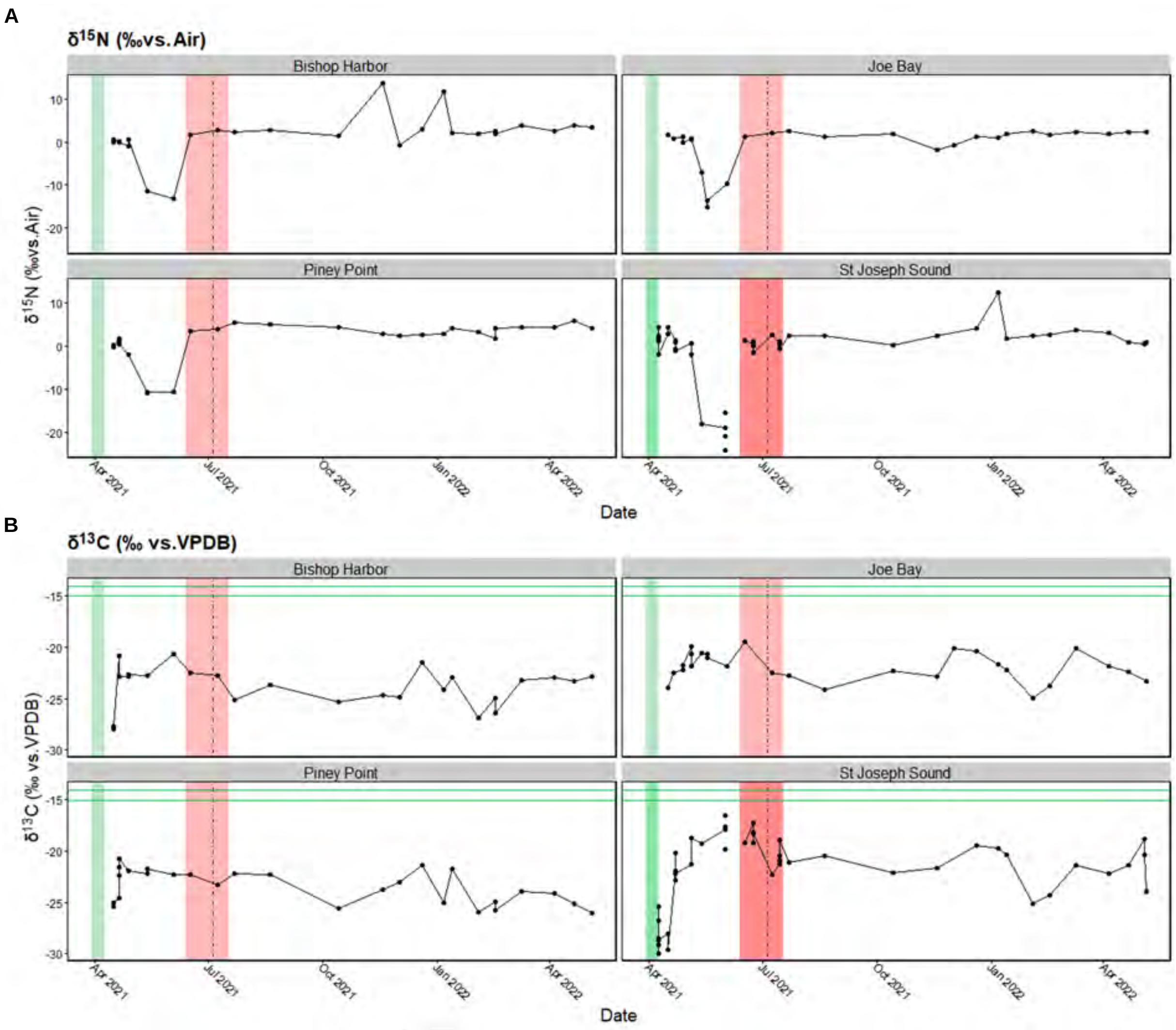

FIGURE 6
Stable isotope values for **(A)** nitrogen and **(B)** carbon in suspended particulate material (SPM). Values from the Piney Point discharge are shown with the horizontal green line. The Piney Point event (March 30th – April 9th, 2021) is denoted by the green line, the period with maximum (>10^5 cells L^{-1}) *Karenia brevis* cell counts (Beck et al., 2022) is shown in the red box, and the date of tropical storm Elsa (July 5th, 2021) is shown with the vertical dashed black line.

et al., 2019). High nutrient discharge from the Piney Point reservoir was suspected to contribute to the high biomass of *K. brevis* observed in the Piney Point region in June and July. Once *K. brevis* reaches the nearshore, terrestrial nutrient sources may influence bloom conditions, and several recent studies have observed positive relationships between elevated nutrient concentrations in discharges from local coastal watersheds and the intensity of red tide events (Medina et al., 2020, 2022; Phlips et al., 2023). However, further research is needed to define whether the high *K. brevis* biomass was associated with autochthonous production in the region, or allochthonous introduction of *K. brevis* from Tampa Bay, although evidence suggests both occurred during this event.

4.3. Suspended particulate material

Stable isotopes of N have been utilized in Tampa Bay and other coastal ecosystems to evaluate contributions from N sources and investigate N cycling, and our investigation of particulate $\delta^{13}C$ and $\delta^{15}N$ values revealed that Piney Point discharge had a unique SPM source signature. The discharge water SPM had an exceptionally low $\delta^{15}N$ value of $-17.88‰ \pm 0.76$ ($n=5$), and a $\delta^{13}C$ value of $-15.23‰ \pm 0.53$ ($n=5$). A $\delta^{15}N$ value of $-17.88‰$ is unusually low and is considerably lower than values reported for inorganic fertilizers, which can be as low as ~ $-10‰$ (Bateman and Kelly, 2007). In Tampa Bay, particulate and dissolved N stable isotopes have been used to identify N sources in stormwater runoff (Jani et al., 2020), constrain nutrient sources for *K. brevis* blooms (Havens, 2004), and asses N sources within the Gulf of Mexico (Knapp et al., 2021), and our unusually low value makes the $\delta^{15}N$ value of Piney Point SPM unique, and much more depleted, relative to other nutrient sources in the region. Local rainfall nitrate (NO_3^-) values range from -4.42 to 5.69‰, stormwater runoff $\delta^{15}N$-NO_3^- values range from -9.72 to 8.06‰, particulate organic N values range from -1.99 to 6.27‰, and local vegetation sources range from -1.70 to -0.83 ‰ (*Quercus virginia* leaves), 1.55 to 1.60‰ (*Quercus virginia* acorns), and -1.93 to 0.68‰ (*Stenotaphrum secundatum* grass clippings; Jani et al., 2020). Additionally, the Piney Point SPM $\delta^{15}N$ values are much lower than those reported for particulate N in the Gulf

of Mexico (1.6–5.0‰; Knapp et al., 2021). The only available published study that reported exceptionally low $\delta^{15}N$ values comparable to ours was a study of seagrass meadows of *Halodule uninervis* in Qatar, which documented $\delta^{15}N$ values as low as ~ −12.4‰, which was attributed to undefined but localized sediment processes (Walton et al., 2016).

This unusual $\delta^{15}N$ value is likely due to the unique characteristics of the reservoir and the water discharged from it. The discharge water was not pure diammonium phosphate, but rather a combination of waste derived from the production of diammonium phosphate, seawater from dredging operations, and rainwater, which have created unique conditions within the reservoir since it was partially filled in 2011 (Beck et al., 2022). Thus, the SPM collected from the reservoir contained particulate material that included phytoplankton and other microorganisms that were growing in the reservoir water, and as such, should not be expected to have $\delta^{15}N$ values that exactly resemble ammonium (NH_4^+) fertilizer. Given the novel growth conditions presented at the reservoir, it is likely that the highly depleted values seen in the discharge water in April 2021 (−17.88‰ ± 0.76), and in the reservoir water in October 2021 (−19.15‰ ± 0.05), were driven by isotope fractionation associated with ammonium transport and assimilation within the reservoir. Differences between the April and October $\delta^{15}N$ and nutrient values are likely from on-site treatment technologies used since April 2021 to reduce total P and total N within the reservoir.

Stable isotope values of $\delta^{15}N$ can be influenced by various isotopic fractionation pathways which we suggest explains the extreme $\delta^{15}N$ values we observed. Many phytoplankton and other microorganisms preferentially utilize NH_4^+ rather than NO_3^-. When ammonium is transported and assimilated by phytoplankton or other microorganisms, isotopic fractionation can occur when they preferentially utilize the light (^{14}N) isotope and leave the heavy ^{15}N isotope behind. This process can be concentration dependent, and when the ammonium concentration is higher, organisms discriminate more against the heavy isotope (^{15}N) and take up more of the lighter (^{14}N) isotope. This transport and assimilation of ^{14}N into their biomass decreases the relative proportion of ^{15}N in their biomass, and subsequently results in lower $\delta^{15}N$ values of the SPM ($\delta^{15}N_{SPM}$). We hypothesize that, under the extremely high (~210 mg L^{-1}) ammonium concentrations in the Piney Point reservoir, this isotope fractionation occurred to such an extent that it resulted in extremely low $\delta^{15}N$ values observed in the SPM of the reservoir.

While no laboratory studies to date have explored isotopic fractionation associated with ammonium concentrations as high as those in the study reservoir, Liu et al. (2015) reported the occurrence of concentration dependent isotopic fractionation when *Chlorella vulgaris* F1068 was grown in media with 4, 10 and 50 mg L^{-1} ammonium. *C. vulgaris* F1068 is a member of the division Chlorophyta, which was also the division of the dominant alga identified in the Piney Point reservoir. While the maximum *C. vulgaris* F1068 growth rate was seen at 4 mg L^{-1}, this species is capable of tolerating high (50 mg L^{-1}) concentrations of ammonium (Liu et al., 2015). While Liu et al. (2015) did not quantify the isotope enrichment factor (ε; a measure of isotopic discrimination against heavier isotopes) at 50 mg L^{-1}, they found an ε of −2.37‰ when *C. vulgaris* was grown at 10 mg L^{-1} ammonium, and that there was greater discrimination against the heavy isotope when *C. vulgaris* was grown under higher ammonium concentrations (Liu et al., 2015). Concentration dependent isotopic fractionation is not solely limited to members of Chlorophyta, as another laboratory study found that ε values of the diatom *Skeletonema* significantly decreased from −7.8‰ to −27.2‰ when grown on increasing concentrations of ammonium, indicating that when ammonium concentrations are higher, ^{14}N is incorporated faster than ^{15}N, thereby depleting (lowering) the $\delta^{15}N$ value of the phytoplankton and SPM (Pennock et al., 1996).

Anomalously low SPM $\delta^{15}N$ values seen at our study sites in May and June of 2021 suggest that there was incorporation of highly depleted Piney Point discharge into particulate material in the region. Previous work in Tampa Bay has suggested that *K. brevis* utilizes sources with low $\delta^{15}N$ values (Havens, 2004), however, the low SPM $\delta^{15}N$ values occurred prior to the dates of the peak *K. brevis* bloom, suggesting that the NH_4^+ from the discharge water was either (1) taken up by fast growing diatoms in May/June and incorporated into phytoplankton biomass/SPM; or (2) NH_4^+ may have been utilized during the early stage of the bloom, as initially low *K. brevis* cell counts were seen in lower Tampa Bay as early as the week of April 18th, 2021. However, we do not have sufficient evidence to explicitly evaluate these two scenarios.

The discharge water had a $\delta^{13}C$ value of −15.23‰ ± 0.53, which is within the range of bacteria or C4 terrestrial organic matter (Lamb et al., 2006). All sites exhibited a increase in $\delta^{13}C$ values concomitant with the decrease in $\delta^{15}N$ values, suggesting that C derived from the Piney Point discharge was also incorporated into SPM at the same time that $\delta^{15}N$ and C:N values declined. Interestingly, while phytoplankton biomass was lower overall at the reference site, St. Joseph Sound, the same trends in SPM stable isotope values were seen in the reference site. This may be an indication of the export of discharge C and N into regions outside of the bay, which is supported by initial findings from Liu et al. (2021) that showed the discharge was gradually flushed out of the bay and into adjacent coastal waters (Liu et al., 2021). The persistence of highly depleted SPM $\delta^{15}N$ values approximately 50 km from the discharge site is unexpected, but other regions distant to the discharge site, such as upper Sarasota Bay were also likely affected by the discharged waters (Tomasko, 2023). Additionally, we found that the reference site had elevated orthoP values in April 2021 relative to April 2022, suggesting that orthoP from the discharge was also transported to the reference site.

It must be emphasized that while the stable isotope values reported here indicate a transport of discharge outside of the bay, we did not observe large, associated shifts in chlorophyll values and phytoplankton community structure at the reference site, suggesting that, even if the SPM at the reference site reflects N contributions from the Piney Point discharge, these values may not have had adverse ecological effects at this location on the phytoplankton community. However, it should be noted that the released nutrients may have had other fates such as uptake into macroalgae and seagrasses, as well as deposition into bay sediments, both of which may have important implications for the long-term health of the Bay. For example, macroalgae blooms have contributed to seagrass losses throughout the Bay, which have been ongoing since before Piney Point. After Piney Point, *Ulva* was abundant in Hillsborough Bay and *Dapis* was abundant in most of the Bay (Tomasko, 2023), which may adversely affect seagrass meadows. Deposition into Bay sediments may also be an important mechanism by which nutrients from the discharge may have been removed from the water column and stored in the sediments. This legacy nutrient source may have implications for future water quality, as sedimentary resuspension, and fluxes of inorganic nutrients from sediments can provide an important source of nutrients to primary producers,

including phytoplankton and HABs (Dixon et al., 2014). Further investigation into macroalgae and seagrass stable isotope values and sedimentary records from the study area will provide a more complete picture of nutrient effects on the ecosystem.

4.4. Tropical storms and export of piney point discharge to surrounding areas

In addition to capturing some of the effects of the Piney Point discharge on Tampa Bay's phytoplankton communities and particulate material, we also detected a signal of Tropical Storm Elsa on the water quality of different regions within the Bay. The passage of tropical storm Elsa through the Tampa Bay area (July 5th, 2021) resulted in approximately 8–18 cm of rain delivered to the west coast of Florida (Cangialosi et al., 2022), and increased stream flows of the Anclote River and Little Manatee River which are tributaries to our study area (USGS, 2021a,b). The maximum stream flow reported for the Anclote river (USGS monitoring location 02310000), near the reference site St. Joseph Sound, was 954 $ft^3\ s^{-1}$ on July 10th, 2021, compared to 5.05 $ft^3\ s^{-1}$ during pre-storm conditions on July 1st, 2021 (USGS, 2021a), and the maximum stream flow reported for the Little Manatee River (USGS monitoring location 02300500), closest to the lower Tampa Bay sites, was 1,510 $ft^3\ s^{-1}$ on July 8th compared to 43.1 $ft^3\ s^{-1}$ during pre-storm conditions on June 28th, indicating that there were considerable increases in stream flow rates associated with this storm event.

The increased rainfall and streamflow into the study sites was associated with lower salinities, particularly at the lower bay sites. A decrease in fDOM, extracted and *in situ* chlorophyll, as well as PE were seen at the lower Tampa Bay sites, likely due to dilution of terrestrial DOM, in the case of fDOM, and possibly due to flushing of phytoplankton from the bay, in the case of chlorophyll and PE. The effects of Tropical Storm Elsa also likely influenced particulate TC values, as the lowest TC values ($0.2 \pm 0.02\%$) at Bishop Harbor and St. Joseph Sound site were seen immediately following the storm and likely driven by a dilution effect from freshwater inflows. We also observed a decline in C:N values at these sites, likely driven by an influx of N derived from the surrounding watershed associated with the storm. Past work in the region found that after some storm events, the concentration of all forms of N decreased, which was attributed to a dilution effect followed by a slight increase in TN concentrations after rainfall ceased (Jani et al., 2020). This was seen in 3 out of 4 sites in this study following the passage of Tropical Storm Elsa, where particulate N values exhibited an initial decrease after the storm, followed by a slight increase at Bishop Harbor and St. Joseph Sound sites, highlighting the important role that tropical storms play in influencing nutrient fluxes from terrestrial systems.

In addition, the occurrence of tropical storms and hurricanes can have interactive effects with built infrastructure, potentially resulting in increased threats to coastal systems and changes in nutrient regimes. For example, the capacity of the holding reservoirs at Piney Point had decreased due to rain events and tropical storms in the years prior to the event (Beck et al., 2022) increasing the risk of overflow or breaching which likely contributed to the 2021 event. Closure activities at the site are now centered on reducing the accumulation of rainfall within the wastewater reservoir system. As tropical storms and hurricanes are projected to increase in frequency and intensity, events such as the Piney Point 2021 wastewater discharge emphasize the vulnerability of coastal infrastructure and the potential ongoing threats these vulnerable facilities pose to coastal ecosystems.

5. Conclusion

Here we document changes in phytoplankton community composition, water quality, and SPM in the year following the 2021 Piney Point discharge event. Soon after the discharge, elevated diatom biomass was seen in the lower Tampa Bay sites, followed by high biomass of the harmful algae *K. brevis* in the summer of 2021. Nitrogen stable isotope values in SPM were very low in May and June of 2021 and were similar to $\delta^{15}N$ values from the discharge, suggesting that N from the Piney Point discharge was incorporated into SPM in the region. Low $\delta^{15}N$ values were also seen in the SPM samples collected from the reference site, St. Joseph Sound, and higher orthophosphate concentrations were seen at the site in April 2021 versus 2022, further suggesting that some of the Piney Point discharge was exported out of Tampa Bay proper. While the stable isotope values reported here indicate a transport of discharge outside of the bay, chlorophyll values and phytoplankton communities did not exhibit notable shifts at the reference site, suggesting that, even though SPM at the reference site reflects N contributions from the Piney Point discharge, these values may not have had adverse ecological effects at this location, at least from a phytoplankton perspective. While onsite treatment technologies have reduced the N and P concentrations in the reservoir, and have reduced the risk to nearby coastal ecosystems, the Piney Point event highlights the threat that industrial infrastructure failures can cause along Florida's coastlines. In addition, these vulnerabilities should be assessed with other factors, such as estuarine flushing rates, water residence times, climatic factors, and storms and hurricanes, which can also influence the initiation and persistence of HABs and the health of Florida's coastal ecosystems (Phlips et al., 2020; Tomasko et al., 2020). Here, the effects of Tropical Storm Elsa showed changes in water quality in the region, and storms such as Hurricane Ian, which passed through the region in September 2022, may also have interactive effects with the discharge-impacted regions in the Bay. This work underscores the need for comprehensive nutrient management strategies and convergent research to assess and manage the full range of consequences associated with anthropogenic nutrient inputs into coastal ecosystems. Ongoing and anticipated impacts of accelerated climate change – such as increasing tropical storm intensity, temperatures, rainfall, and sea level rise – will amplify this need.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://github.com/elisemorrison/PineyPoint2021

Author contributions

EM: conceptualization, data collection, field sampling, data curation, formal analysis, methodology, writing – original draft, and

writing – review and editing. EP: conceptualization, data curation, formal analysis, methodology, writing – original draft, and writing – review and editing. SB: data curation, formal analysis, methodology, and writing – review and editing. AC and AA: data collection, field sampling, data curation, methodology, and writing – review and editing. TO: data curation and writing – review and editing. DT: data curation and writing – review and editing. MB and ES: writing – review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2023.1144778/full#supplementary-material

References

Ahlgren, G. (1983). Comparison of methods for estimation of phytoplankton carbon. *Arch. Hydrobiol.* 98, 489–508.

Ajani, P. A., Armbrecht, L. H., Kersten, O., Kohli, G. S., and Murray, S. A. (2016). Diversity, temporal distribution and physiology of the centric diatom *Leptocylindrus Cleve* (Bacillariophyta) from a southern hemisphere upwelling system. *Diatom Res.* 31, 351–365. doi: 10.1080/0269249X.2016.1260058

American Public Health Association (2005). *Standard methods for the examination of water and wastewater*. Washington, DC, USA: American Public Health Association (APHA).

Anderson, S. I., Franzè, G., Kling, J. D., Wilburn, P., Kremer, C. T., Menden-Deuer, S., et al. (2022). The interactive effects of temperature and nutrients on a spring phytoplankton community. *Limnol. Oceanogr.* 67, 634–645. doi: 10.1002/lno.12023

Anderson, S. I., and Rynearson, T. A. (2020). Variability approaching the thermal limits can drive diatom community dynamics. *Limnol. Oceanogr.* 65, 1961–1973. doi: 10.1002/lno.11430

Badylak, S., and Phlips, E. (2004). Spatial and temporal patterns of phytoplankton composition in subtropical coastal lagoon, the Indian River lagoon, Florida, USA. *J. Plankton Res.* 26, 1229–1247. doi: 10.1093/plankt/fbh114

Badylak, S., Phlips, E. J., Baker, P., Fajans, J., and Boler, R. (2007). Distributions of phytoplankton in Tampa Bay estuary, USA 2002-2003. *Bull. Mar. Sci.* 80, 295–317.

Badylak, S., Phlips, E. J., and Mathews, A. L. (2014). *Akashiwo sanguinea* (Dinophyceae) blooms in a sub-tropical estuary: an alga for all seasons. *Plank. Benthos Res.* 9, 147–155. doi: 10.3800/pbr.9.147

Balzano, S., Sarno, D., and Kooistra, W. H. (2011). Effects of salinity on the growth rate and morphology of ten *Skeletonema* strains. *J. Plankton Res.* 33, 937–945. doi: 10.1093/plankt/fbq150

Bateman, A. S., and Kelly, S. D. (2007). Fertilizer nitrogen isotope signatures. *Isot. Environ. Health Stud.* 43, 237–247. doi: 10.1080/10256010701550732

Beck, M. W., Altieri, A., Angelini, C., Burke, M. C., Chen, J., Chin, D. W., et al. (2022). Initial estuarine response to inorganic nutrient inputs from a legacy mining facility adjacent to Tampa Bay Florida. *Mar. Pollut. Bull.* 178:113598. doi: 10.1016/j.marpolbul.2022.113598

Beck, M. W., Sherwood, E. T., Henkel, J. R., Dorans, K., Ireland, K., and Varela, P. (2019). Assessment of the cumulative effects of restoration activities on water quality in Tampa Bay, Florida. *Estuar. Coasts* 42, 1774–1791. doi: 10.1007/s12237-019-00619-w

Beusen, A., Van Beek, L., Bouwman, A., Mogollón, J., and Middelburg, J. (2015). Coupling global models for hydrology and nutrient loading to simulate nitrogen and phosphorus retention in surface water–description of IMAGE–GNM and analysis of performance. *Geosci. Model Dev.* 8, 4045–4067. doi: 10.5194/gmd-8-4045-2015

Brand, L. E. (1984). The salinity tolerance of forty-six marine phytoplankton isolates. *Estuar. Coast. Shelf Sci.* 18, 543–556. doi: 10.1016/0272-7714(84)90089-1

Buschmann, A. H., Riquelme, V. A., Hernández-González, M. C., Varela, D., Jiménez, J. E., Henríquez, L. A., et al. (2006). A review of the impacts of salmonid farming on marine coastal ecosystems in the Southeast Pacific. *ICES J. Mar. Sci.* 63, 1338–1345. doi: 10.1016/j.icesjms.2006.04.021

Cangialosi, J. P., Delgado, S., and Berg, R. (2022). *National Hurricane Center Tropical Cyclone Report Hurricane Elsa (AL052021)* Miami FL: ELSA.

Cermeño, P., Lee, J.-B., Wyman, K., Schofield, O., and Falkowski, P. G. (2011). Competitive dynamics in two species of marine phytoplankton under non-equilibrium conditions. *Mar. Ecol. Prog. Ser.* 429, 19–28. doi: 10.3354/meps09088

Chen, J., Weisberg, R. H., Liu, Y., and Zheng, L. (2018). The Tampa Bay coastal ocean model performance for hurricane Irma. *Mar. Technol. Soc. J.* 52, 33–42. doi: 10.4031/MTSJ.52.3.6

Chen, J., Weisberg, R. H., Liu, Y., Zheng, L., and Zhu, J. (2019). On the momentum balance of Tampa Bay. *J. Geophys. Res. Oceans* 124, 4492–4510. doi: 10.1029/2018JC014890

Cloern, J. E. (2001). Our evolving conceptual model of the coastal eutrophication problem. *Mar. Ecol. Prog. Ser.* 210, 223–253. doi: 10.3354/meps210223

Deangelis, B. M., Sutton-Grier, A. E., Colden, A., Arkema, K. K., Baillie, C. J., Bennett, R. O., et al. (2020). Social factors key to landscape-scale coastal restoration: lessons learned from three US case studies. *Sustainability* 12:869. doi: 10.3390/su12030869

Dixon, L. K., Murphy, P. J., Becker, N. M., and Charniga, C. M. (2014). The potential role of benthic nutrient flux in support of *Karenia* blooms in West Florida (USA) estuaries and the nearshore Gulf of Mexico. *Harmful Algae* 38, 30–39. doi: 10.1016/j.hal.2014.04.005

Doney, S. C., Ruckelshaus, M., Emmett Duffy, J., Barry, J. P., Chan, F., English, C. A., et al. (2012). Climate change impacts on marine ecosystems. *Annu. Rev. Mar. Sci.* 4, 11–37. doi: 10.1146/annurev-marine-041911-111611

Eppley, R. W. (1977). The growth and culture of diatoms. *Biol. Diatoms* 32:2.

Fahnenstiel, G. L., and Carrick, H. J. (1992). Phototrophic picoplankton in lakes Huron and Michigan: abundance, distribution, composition, and contribution to biomass and production. *Can. J. Fish. Aquat. Sci.* 49, 379–388. doi: 10.1139/f92-043

Fleming, L. E., Kirkpatrick, B., Backer, L. C., Bean, J. A., Wanner, A., Dalpra, D., et al. (2005). Initial evaluation of the effects of aerosolized Florida red tide toxins (brevetoxins) in persons with asthma. *Environ. Health Perspect.* 113, 650–657. doi: 10.1289/ehp.7500

Florida Department of Environmental Protection (2021). Piney point update - April 6, 2021 [online]. Available at: https://protectingfloridatogether.gov/node/285# (Accessed October 1, 2023).

Florida Fish and Wildlife Conservation Commission (2022). Fish kill database search result report [online]. Available at: https://app.myfwc.com/FWRI/FishKillReport/ReportWorkSheet.aspx (Accessed 14 January, 2023).

Garrett, M., Wolny, J., Truby, E., Heil, C., and Kovach, C. (2011). Harmful algal bloom species and phosphate-processing effluent: field and laboratory studies. *Mar. Pollut. Bull.* 62, 596–601. doi: 10.1016/j.marpolbul.2010.11.017

Glibert, P. M. (2020). Harmful algae at the complex nexus of eutrophication and climate change. *Harmful Algae* 91:101583. doi: 10.1016/j.hal.2019.03.001

Glibert, P. M., Icarus Allen, J., Artioli, Y., Beusen, A., Bouwman, L., Harle, J., et al. (2014). Vulnerability of coastal ecosystems to changes in harmful algal bloom distribution in response to climate change: projections based on model analysis. *Glob. Chang. Biol.* 20, 3845–3858. doi: 10.1111/gcb.12662

Gobler, C. J. (2020). Climate change and harmful algal blooms: insights and perspective. *Harmful Algae* 91:101731. doi: 10.1016/j.hal.2019.101731

Greening, H., Janicki, A., Sherwood, E. T., Pribble, R., and Johansson, J. O. R. (2014). Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA. *Estuar. Coast. Shelf Sci.* 151, A1–A16. doi: 10.1016/j.ecss.2014.10.003

Griffith, A. W., and Gobler, C. J. (2020). Harmful algal blooms: a climate change co-stressor in marine and freshwater ecosystems. *Harmful Algae* 91:101590. doi: 10.1016/j.hal.2019.03.008

Grill, G., Lehner, B., Lumsdon, A. E., Macdonald, G. K., Zarfl, C., and Liermann, C. R. (2015). An index-based framework for assessing patterns and trends in river fragmentation and flow regulation by global dams at multiple scales. *Environ. Res. Lett.* 10:015001. doi: 10.1088/1748-9326/10/1/015001

Hagy Iii, J. D., Kreakie, B. J., Pelletier, M. C., Nojavan, F., Kiddon, J. A., and Oczkowski, A. J. (2022). Quantifying coastal ecosystem trophic state at a macroscale using a Bayesian analytical framework. *Ecol. Indic.* 142:109267, –109212. doi: 10.1016/j.ecolind.2022.109267

Hart, J., Phlips, E., Badylak, S., Dix, N., Petrinec, K., Mathews, A., et al. (2015). Phytoplankton biomass and composition in a well-flushed, sub-tropical estuary: the contrasting effects of hydrology, nutrient loads and allochthonous influences. *Mar. Environ. Res.* 112, 9–20. doi: 10.1016/j.marenvres.2015.08.010

Havens, J. A. (2004). *A stable isotopic examination of particulate organic matter during Karenia brevis blooms on the central West Florida shelf: Hints at nitrogen sources in oligotrophic waters.*

Heil, C. A., Dixon, L. K., Hall, E., Garrett, M., Lenes, J. M., Oneil, J. M., et al. (2014). Blooms of *Karenia brevis* (Davis) G. Hansen & Ø. Moestrup on the West Florida shelf: nutrient sources and potential management strategies based on a multi-year regional study. *Harmful Algae* 38, 127–140. doi: 10.1016/j.hal.2014.07.016

Heil, C. A., and Muni-Morgan, A. L. (2021). Florida's harmful algal bloom (HAB) problem: escalating risks to human, environmental and economic health with climate change. *Front. Ecol. Evol.* 9:646080. doi: 10.3389/fevo.2021.646080

Heisler, J., Glibert, P. M., Burkholder, J. M., Anderson, D. M., Cochlan, W., Dennison, W. C., et al. (2008). Eutrophication and harmful algal blooms: a scientific consensus. *Harmful Algae* 8, 3–13. doi: 10.1016/j.hal.2008.08.006

Herren, L., Brewton, R., Wilking, L., Tarnowski, M., Vogel, M., and Lapointe, B. (2021). Septic systems drive nutrient enrichment of groundwaters and eutrophication in the urbanized Indian River lagoon. *Florida. Mar. Pollut. Bull.* 172:112928. doi: 10.1016/j.marpolbul.2021.112928

Hoegh-Guldberg, O., and Bruno, J. F. (2010). The impact of climate change on the world's marine ecosystems. *Science* 328, 1523–1528. doi: 10.1126/science.1189930

Ianora, A., Casotti, R., Bastianini, M., Brunet, C., D'ippolito, G., Acri, F., et al. (2008). Low reproductive success for copepods during a bloom of the non-aldehyde-producing diatom *Cerataulina pelagica* in the North Adriatic Sea. *Mar. Ecol.* 29, 399–410. doi: 10.1111/j.1439-0485.2008.00226.x

Irigoien, X., Flynn, K., and Harris, R. (2005). Phytoplankton blooms: a "loophole" in microzooplankton grazing impact? *J. Plankton Res.* 27, 313–321. doi: 10.1093/plankt/fbi011

Jani, J., Yang, Y.-Y., Lusk, M. G., and Toor, G. S. (2020). Composition of nitrogen in urban residential stormwater runoff: concentrations, loads, and source characterization of nitrate and organic nitrogen. *PLoS One* 15:e0229715. doi: 10.1371/journal.pone.0229715

Karthik, R., Padmavati, G., Elangovan, S. S., and Sachithanandam, V. (2017). Monitoring the diatom bloom of *Leptocylindrus danicus* (Cleve 1889, Bacillariophyceae) in the coastal waters of south Andaman Island. *Indian J. Geo-Mar. Sci.* 46, 958–965. http://nopr.niscpr.res.in/handle/123456789/41662

Kirkpatrick, B., Fleming, L. E., Squicciarini, D., Backer, L. C., Clark, R., Abraham, W., et al. (2004). Literature review of Florida red tide: implications for human health effects. *Harmful Algae* 3, 99–115. doi: 10.1016/j.hal.2003.08.005

Knapp, A. N., Thomas, R. K., Stukel, M. R., Kelly, T. B., Landry, M. R., Selph, K. E., et al. (2021). Constraining the sources of nitrogen fueling export production in the Gulf of Mexico using nitrogen isotope budgets. *J. Plankton Res.* 44, 692–710.

Lamb, A. L., Wilson, G. P., and Leng, M. J. (2006). A review of coastal palaeoclimate and relative sea-level reconstructions using δ13C and C/N ratios in organic material. *Earth Sci. Rev.* 75, 29–57. doi: 10.1016/j.earscirev.2005.10.003

Landsberg, J., Flewelling, L., and Naar, J. (2009). *Karenia brevis* red tides, brevetoxins in the food web, and impacts on natural resources: decadal advancements. *Harmful Algae* 8, 598–607. doi: 10.1016/j.hal.2008.11.010

Lassus, P., Chaumérat, N., Hess, P., and Nézan, E. (2015). Toxic and harmful microalgae of the World Ocean, International Society for the Study of harmful algae and the United Nations ….

Lehner, B., Liermann, C. R., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., et al. (2011). High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. *Front. Ecol. Environ.* 9, 494–502. doi: 10.1890/100125

Litchman, E., Klausmeier, C. A., Schofield, O. M., and Falkowski, P. G. (2007). The role of functional traits and trade-offs in structuring phytoplankton communities: scaling from cellular to ecosystem level. *Ecol. Lett.* 10, 1170–1181. doi: 10.1111/j.1461-0248.2007.01117.x

Liu, N., Li, F., Ge, F., Tao, N., Zhou, Q., and Wong, M. (2015). Mechanisms of ammonium assimilation by *Chlorella vulgaris* F1068: isotope fractionation and proteomic approaches. *Bioresour. Technol.* 190, 307–314. doi: 10.1016/j.biortech.2015.04.024

Liu, Y., Weisberg, R., Zheng, L., Sun, Y., and Chen, J. Nowcast/forecast of the Tampa Bay, piney point effluent plume: a rapid response AGU fall Meeting Abstracts (2021). OS35B–1036.

Lundholm, N., Churro, C., Fraga, S., Hoppenrath, M., Iwataki, M., Larsen, J., et al. (Eds) (2009 onwards). IOC-UNESCO Taxonomic Reference List of Harmful Micro Algae. Accessed at https://www.marinespecies.org/hab on yyyy-mm-dd. doi: 10.14284/362

Maavara, T., Parsons, C. T., Ridenour, C., Stojanovic, S., Dürr, H. H., Powley, H. R., et al. (2015). Global phosphorus retention by river damming. *Proc. Natl. Acad. Sci. U. S. A.* 112, 15603–15608. doi: 10.1073/pnas.1511797112

Martin, J. L., and Legresley, M. (2014). Phytoplankton monitoring in the Western isles region of the bay of Fundy during 2003–2006, Biological Station: Fisheries and Oceans Canada.

Matsubara, T., Nagasoe, S., Yamasaki, Y., Shikata, T., Shimasaki, Y., Oshima, Y., et al. (2007). Effects of temperature, salinity, and irradiance on the growth of the dinoflagellate *Akashiwo sanguinea*. *J. Exp. Mar. Biol. Ecol.* 342, 226–230. doi: 10.1016/j.jembe.2006.09.013

Medina, M., Huffaker, R., Jawitz, J. W., and Muñoz-Carpena, R. (2020). Seasonal dynamics of terrestrially sourced nitrogen influenced *Karenia brevis* blooms off Florida's southern Gulf Coast. *Harmful Algae* 98:101900. doi: 10.1016/j.hal.2020.101900

Medina, M., Kaplan, D., Milbrandt, E. C., Tomasko, D., Huffaker, R., and Angelini, C. (2022). Nitrogen-enriched discharges from a highly managed watershed intensify red tide (*Karenia brevis*) blooms in Southwest Florida. *Sci. Total Environ.* 827:154149. doi: 10.1016/j.scitotenv.2022.154149

Metcalf, J., Banack, S., Wessel, R., Lester, M., Pim, J., Cassani, J., et al. (2021). Toxin analysis of freshwater cyanobacterial and marine harmful algal blooms on the west coast of Florida and implications for estuarine environments. *Neurotox. Res.* 39, 27–35. doi: 10.1007/s12640-020-00248-3

Milbrandt, E. C., Martignette, A., Thompson, M., Bartleson, R., Phlips, E., Badylak, S., et al. (2021). Geospatial distribution of hypoxia associated with a *Karenia brevis* bloom. *Estuar. Coast. Shelf Sci.* 259:107446. doi: 10.1016/j.ecss.2021.107446

Montagnes, D. J., and Franklin, M. (2001). Effect of temperature on diatom volume, growth rate, and carbon and nitrogen content: reconsidering some paradigms. *Limnol. Oceanogr.* 46, 2008–2018. doi: 10.4319/lo.2001.46.8.2008

Nelson, N. G., Cuchiara, M. L., Hendren, C. O., Jones, J. L., and Marshall, A.-M. (2021). Hazardous spills at retired fertilizer manufacturing plants will continue to occur in the absence of scientific innovation and regulatory enforcement. *Environ. Sci. Technol.* 55, 16267–16269. doi: 10.1021/acs.est.1c05311

Nixon, S. W. (1995). Coastal marine eutrophication: a definition, social causes, and future concerns. *Ophelia* 41, 199–219. doi: 10.1080/00785236.1995.10422044

Oneil, J. M., Davis, T. W., Burford, M. A., and Gobler, C. J. (2012). The rise of harmful cyanobacteria blooms: the potential roles of eutrophication and climate change. *Harmful Algae* 14, 313–334. doi: 10.1016/j.hal.2011.10.027

Paerl, H. W., Valdes, L. M., Peierls, B. L., Adolf, J. E., and Harding, L. J. W. (2006). Anthropogenic and climatic influences on the eutrophication of large estuarine ecosystems. *Limnol. Oceanogr.* 51, 448–462. doi: 10.4319/lo.2006.51.1_part_2.0448

Pennock, J. R., Velinsky, D. J., Ludlam, J. M., Sharp, J. H., and Fogel, M. L. (1996). Isotopic fractionation of ammonium and nitrate during uptake by *Skeletonema costatum*: implications for δ15N dynamics under bloom conditions. *Limnol. Oceanogr.* 41, 451–459. doi: 10.4319/lo.1996.41.3.0451

Phlips, E., Badylak, S., Bledsoe, E., and Cichra, M. (2006). Factors influencing the distribution and abundance of *Pyrodinium bahamense* in coastal ecosystems of Florida. *Mar. Ecol. Prog. Ser.* 322, 99–115. doi: 10.3354/meps322099

Phlips, E. J., Badylak, S., Christman, M. C., and Lasi, M. A. (2010). Climatic trends and temporal patterns of phytoplankton composition, abundance, and succession in the Indian River lagoon, Florida, USA. *Estuar. Coasts* 33, 498–512. doi: 10.1007/s12237-009-9166-8

Phlips, E. J., Badylak, S., Christman, M., Wolny, J., Brame, J., Garland, J., et al. (2011). Scales of temporal and spatial variability in the distribution of harmful algae species in the Indian River lagoon, Florida, USA. *Harmful Algae* 10, 277–290. doi: 10.1016/j.hal.2010.11.001

Phlips, E. J., Badylak, S., and Lynch, T. C. (1999). Blooms of the picoplanktonic cyanobacterium *Synechococcus* in Florida bay, a subtropical inner-shelf lagoon. *Limnol. Oceanogr.* 44, 1166–1175. doi: 10.4319/lo.1999.44.4.1166

Phlips, E., Badylak, S., Matthews, A. L., Milbrandt, E. C. R. M. L., Morrison, E., Nelson, N. G., et al. (2023). Algal blooms in a river-dominated estuary and nearshore region of Florida, USA: the influence of regulated discharges from water control structures on hydrology and nutrient conditions. *Hydrobiologia*. doi: 10.1007/s10750-022-05135-w.

Phlips, E. J., Badylak, S., Nelson, N. G., and Havens, K. E. (2020). Hurricanes, El Niño and harmful algal blooms in two sub-tropical Florida estuaries: direct and indirect impacts. *Sci. Rep.* 10, 1–12. doi: 10.1038/s41598-020-58771-4

Phlips, E., and Mitsui, A. (1982). "Temperature preference and tolerance of aquatic photosynthetic microorganisms [including blue-green algae]," in *CRC handbook of biosolar resources*. eds. A. Mitsui and C. Black (Boca, Florida: CRC Press), 335–361.

Quinlan, E. L., and Phlips, E. J. (2007). Phytoplankton assemblages across the marine to low-salinity transition zone in a Blackwater dominated estuary. *J. Plankton Res.* 29, 401–416. doi: 10.1093/plankt/fbm024

R Core Development Team (2008). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing: Vienna, Austria.

Reynolds, C. S. (2006). *Ecology of Phytoplankton*. Cambridge: Cambridge University Press.

Sartory, D., and Grobbelaar, J. (1984). Extraction of chlorophyll a from freshwater phytoplankton for spectrophotometric analysis. *Hydrobiologia* 114, 177–187. doi: 10.1007/BF00031869

Sherwood, E. T., Greening, H. S., Johansson, J. R., Kaufman, K., and Raulerson, G. E. (2017). Tampa Bay (Florida, USA) documenting seagrass recovery since the 1980's and reviewing the benefits. *Southeast. Geogr.* 57, 294–319. doi: 10.1353/sgo.2017.0026

Sicko-Goad, L. M., Schelske, C. L., and Stoermer, E. F. (1984). Estimation of intracellular carbon and silica content of diatoms from natural assemblages using morphometric techniques 1. *Limnol. Oceanogr.* 29, 1170–1178. doi: 10.4319/lo.1984.29.6.1170

Sin, Y., Hyun, B., Jeong, B., and Soh, H. Y. (2013). Impacts of eutrophic freshwater inputs on water quality and phytoplankton size structure in a temperate estuary altered by a sea dike. *Mar. Environ. Res.* 85, 54–63. doi: 10.1016/j.marenvres.2013.01.001

Smayda, T. J. (1978). "From phytoplankters to biomass". In *Phytoplankton Manual*. ed. A. Sournia (Paris: UNESCO), 273–279.

Steidinger, K. A. (2009). Historical perspective on *Karenia brevis* red tide research in the Gulf of Mexico. *Harmful Algae* 8, 549–561. doi: 10.1016/j.hal.2008.11.009

Stolte, W., and Garcés, E. (2006). "Ecological aspects of harmful algal in situ population growth rates," in *Ecology of harmful algae* (London: Springer).

Strathmann, R. R. (1967). Estimating the organic carbon content of phytoplankton from cell volume or plasma volume 1. *Limnol. Oceanogr.* 12, 411–418. doi: 10.4319/lo.1967.12.3.0411

Sun, J., and Liu, D. (2003). Geometric models for calculating cell biovolume and surface area for phytoplankton. *J. Plankton Res.* 25, 1331–1346. doi: 10.1093/plankt/fbg096

Switzer, T. S., Tyler-Jedlund, A. J., Rogers, K. R., Grier, H., Mcmichael, R. H., and Fox, S. (2011). Response of estuarine nekton to the regulated discharge of treated phosphate-production process water. TR-16. Florida Fish and Wildlife Conservation Commission. Fish and Wildlife Research Institute. Technical Report. St. Petersburg, FL. http://hdl.handle.net/1834/41127

Tampa Bay Estuary Program (2022). State of the bay 2019-2021. Available at: https://tbep.org/estuary/state-of-the-bay/ (Accessed October 1, 2023).

Tampa Bay Nitrogen Management Consortium (TBNMC) (2022). Tampa Bay Reasonable Assurance Compliance Assessment Report. Available at: https://tbep-tech.github.io/tbnmc-compliance-assessment-2022/index.html

Taylor, F., Taylor, N., and Walsby, J. (1985). A bloom of the planktonic diatom, *Cerataulina pelagica*, off the coast of northeastern New Zealand in 1983, and its contribution to an associated mortality of fish and benthic fauna. *Internationale Revue der gesamten Hydrobiologie und Hydrographie* 70, 773–795. doi: 10.1002/iroh.19850700602

Tomasko, D. (2023). Ecological impacts to Sarasota Bay from Piney Point discharges - examining the evidence. *Florida Scientist.*

Tomasko, D., Alderson, M., Burnes, R., Hecker, J., Iadevaia, N., Leverone, J., et al. (2020). The effects of hurricane Irma on seagrass meadows in previously eutrophic estuaries in Southwest Florida (USA). *Mar. Pollut. Bull.* 156:111247. doi: 10.1016/j.marpolbul.2020.111247

Tomasko, D., Alderson, M., Burnes, R., Hecker, J., Leverone, J., Raulerson, G., et al. (2018). Widespread recovery of seagrass coverage in Southwest Florida (USA): temporal and spatial trends and management actions responsible for success. *Mar. Pollut. Bull.* 135, 1128–1137. doi: 10.1016/j.marpolbul.2018.08.049

USGS (2021a). USGS water data Anclote River [online]. Available at: https://waterdata.usgs.gov/monitoring-location/02310000/#parameterCode=00060&startDT=2021-04-01&endDT=2022-05-01 (Accessed November 1, 2023).

USGS (2021b). USGS water data little Manatee River [online] Available at: https://waterdata.usgs.gov/monitoring-location/02300500/#parameterCode=00060&startDT=2021-04-01&endDT=2022-05-01 (Accessed November 1, 2023).

Utermohl, H. (1958). To the perfection of quantitative phytoplankton methodology. *Mitt. Int. Ver. Theor. Angew. Limnol.* 9, 1–38.

Vargo, G. A. (2009). A brief summary of the physiology and ecology of *Karenia brevis* Davis (G. Hansen and Moestrup comb. nov.) red tides on the West Florida shelf and of hypotheses posed for their initiation, growth, maintenance, and termination. *Harmful Algae* 8, 573–584. doi: 10.1016/j.hal.2008.11.002

Verity, P. G., Robertson, C. Y., Tronzo, C. R., Andrews, M. G., Nelson, J. R., and Sieracki, M. E. (1992). Relationships between cell volume and the carbon and nitrogen content of marine photosynthetic nanoplankton. *Limnol. Oceanogr.* 37, 1434–1446. doi: 10.4319/lo.1992.37.7.1434

Walton, M., Al-Maslamani, I., Haddaway, N., Kennedy, H., Castillo, A., Al-Ansari, E., et al. (2016). Extreme 15N depletion in seagrasses. *Estuar. Coasts* 39, 1709–1723. doi: 10.1007/s12237-016-0103-3

Webster, P. J., Holland, G. J., Curry, J. A., and Chang, H.-R. (2005). Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309, 1844–1846. doi: 10.1126/science.1116448

Weisberg, R. H., Liu, Y., Lembke, C., Hu, C., Hubbard, K., and Garrett, M. (2019). The coastal ocean circulation influence on the 2018 West Florida Shelf *K. brevis* red tide bloom. *J. Geophys. Res. Oceans* 124, 2501–2512. doi: 10.1029/2018JC014887

Wetz, M. S., and Yoskowitz, D. W. (2013). An "extreme" future for estuaries? Effects of extreme climatic events on estuarine water quality and ecology. *Mar. Pollut. Bull.* 69, 7–18. doi: 10.1016/j.marpolbul.2013.01.020

Work, K., Havens, K., Sharfstein, B., and East, T. (2005). How important is bacterial carbon to planktonic grazers in a turbid, subtropical lake? *J. Plankton Res.* 27, 357–372. doi: 10.1093/plankt/fbi013

Yates, K., Greening, H., and Morrison, G. (2011). Integrating science and resource management in Tampa Bay, Florida Prepared in partnership with the Tampa Bay Estuary Program.

A large red tide has contributed to more than 600 tons of dead marine life in Florida

By Lauren M. Johnson, CNN

3 minute read · Published 10:04 PM EDT, Mon July 19, 2021

Dead fish from red tide washed up along a waterfront park in St. Petersburg, Florida, on July 9. Arielle Bader/Tampa Bay Times via AP

(CNN) — A red tide has invaded the Gulf Coast of Florida, causing problems for wildlife and the community.

The bacteria that makes up red tide, Karenia brevis, has already killed more than 613 tons of marine life and fish in and around Tampa as of last week, according to local officials.

The Florida Fish and Wildlife Conservation Commission said Friday it had collected 132 samples from the region and found high concentrations of the bacteria in the water in Pinellas and

Hillsborough counties.

Fish kills suspected to be related to red tide were reported in Pasco, Pinellas, Hillsborough, Manatee, Sarasota and Lee counties over the past week, according to the commission, as well as respiratory irritation in many of the same counties.

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3 years ago, a massive algae bloom in Florida killed 2,000 tons of marine life. It's threatening again

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The blooms aren't necessarily red or blue green. The US Centers for Disease Control and Prevention says "blooms can look like foam, scum, mats, or paint on the surface of the water. A bloom can change the color of the water to green, blue, brown, red or another color."

"Red Tide in some parts of Tampa Bay in the past few days tested at ten to 17 times the concentration considered "high," which can cause significant respiratory issues in people as well as fish kills," Pinellas County officials said in a red tide update July 13.

Community members rally to see some change

Members of the Suncoast Surfrider Foundation, a non-profit that works to protect oceans and beaches, and others in the community rallied against the problem Saturday, hoping to bring their concerns to the Florida Gov. Ron DeSantis.

Thomas Paterek, chair of Suncoast Surfrider, told CNN he knew he had to do something when a friend called him in tears because of the dead fish on the beach outside of their water rental business.

"Hearing that phone call sparked a fire in me, to say if nothing is going to be happening, the community needs to lead this," Paterek said.

He said he decided to organize the rally to try to spark immediate change, including closing the nearby Piney Point wastewater reservoir and enacting a state of emergency to help clean up the waterways.

"I think everyone in the community is frustrated," he said. "When you see dead dolphins in the water, when you see dead manatees in the water, dead sea turtles ... when you have captains who have fished in the area for decades say they have never seen anything like this, that is enough to declare a state of emergency and not just say it's another naturally occurring harmful algal bloom."

Large bloom could be connected to Piney Point

Scientists feared a large bloom was imminent after the Piney Point phosphogypsum stack dumped nutrient-rich wastewater into Tampa's waters in April. The elevated concentrations of nitrogen and phosphorus were some of the most concerning descriptors because they are known to fuel phytoplankton growth which can lead to a potentially toxic algal bloom.

"While it's unlikely that we will be able to make a direct correlation between environmental harm manifested in Tampa or Sarasota Bays, it would be absurd to suggest that the impact isn't significant," Justin Bloom, founder of the Suncoast Waterkeeper environmental organization, told CNN in June.

The Florida Department of Health notes that red tides were documented in the southern Gulf of Mexico in the 1700s and along Florida's Gulf Coast since the 1840s. But the Florida Fish and Wildlife Conservation Commission says the microorganism responsible for red tide was not identified until 1946.

And although algae blooms have been recorded for hundreds of years, the Environmental Protection Agency points out: "Nutrient pollution from human activities makes the problem worse, leading to more severe blooms that occur more often."

In 2018, a massive red tide bloom along Florida's southwestern coast killed 2,000 tons of marine life and caused $8 million in business losses.

State and federal agency maps for the summer and fall of 2018 show heavy red tide outbreaks in six counties, from Pinellas in the north to Collier in the south.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

WASTEWATER COMPLIANCE INSPECTION REPORT

Facility Name and Physical Address	WAFR ID	County	Entry Date	Entry Time
Mosaic Fertilizer, LLC New Wales Concentrates Plant 3095 County Road 640 W Mulberry, FL 33860-8875	FL0036421	Polk	10/21/2023	8:00 AM
	Facility Phone #		**Exit Date**	**Exit Time**
	(863)-232-7417		10/21/2023	9:13 AM

LAT	27	°	49	'	57.68	"
LONG	82	°	03	'	11.26	"

Name(s) of Field Representatives(s) and Title	Operator Certification #	Email	Phone
Michael Ward	Environmental Superintendent	Michael.Ward@mosaicco.com	(813) 244-5328
Robert Werner	Senior Manager	Robert.Werner@mosaicco.com	(863)-283-8883

Name & Address of Permittee / Designated Rep.	Title	Email	Phone
Santino A. Provenzano	Director-Environmental	Santino.Provenzano@mosaicco.com	(813)-781-1185

Inspection Type	S	V			Samples Taken(Y/N): N	Sample ID#:	Samples Split (Y/N) : N

☐ **Domestic** X **Industrial**

Recommended Actions: **Please review the following report.**

Name and Signature of Inspector	District Office/Phone Number	Date
Lance Kautz, Environmental Administrator	SWPM/ (813)-470-5909	10/23/2023

1. ♦Records and Reports:

1.1 Observation: On October 20, 2023, the Department received State Watch Office (SWO) incident report number 2023-8712 regarding the release of an unknown amount of process water to the ground. Department Personnel also received verbal notification from facility representatives. The release event occurred near an are of the stack system known as Area of Interest number four (AOI-4).

1.2 Observation: On October 21, 2023, the Department received the Critical Condition Notification and Notice of Pollution (Ref. 403.077, F.S.) regarding a liner tear and loss of an indeterminate amount of process water.

1.3 Observation: At the time of the Site Visit, Department staff reviewed piezometer, seismic, and stack movement monitoring data. Piezometers used to monitor AOI-4 under the secondary liner reported an elevation loss range of 8.3-4.8 ft. Mosaic staff reported that all piezometer instrumentation had been checked and calibrations verified.

2. Facility Site Review:

2.1 Observation: The Drilling Pad, created for the investigation of AOI-4, and side slopes of the surrounding area was observed during the Visit. Technicians were on-site reviewing data and verifying functionality of the active monitoring systems.

2.2 Observation: The underdrain system serving the stack system containing the AOI-4 location still appeared to have active flow, an indication of continued functionality. Mosaic personnel stated that the amount of flow from the underdrain system, visually, appeared to be unchanged and have field-verified a lack of suction in the system.

2.3 Observation: The top of the stack system where the AOI-4 exclusion area is located, contained no ponded water and no visible indication of disturbance.

3. Operation and Maintenance:

3.1 Observation: The larger exclusion area for AOI-4 has been re-established.

3.2 Observation: All process water has been removed from the top of the stack and all phosphogypsum stacking operations for that area have been discontinued.

3.3 Observation: The area where the water loss event occurred is within the zone of capture for the facility's recovery wells. Recent monitoring data results do not indicate any substantive change over the existing trends of the wells' water quality.

3.4 Observation: Mosaic intends to begin drilling operations to investigate the anomaly during the week of 10/23-10/28/2023.

DIGITAL PHOTOGRAPHIC LOG

1. Type of Camera Used: iPhone 12
2. Were the photos altered? NO ___ YES _X_
   Explain yes: Resized
3. Photographer: Lance Kautz

IMG_0045: Stack movement monitoring instrumentation

IMG_0049: View to the west on the AOI-4 drill Pad. Note the piezometers and active calibration/data collection.

IMG_0054: A zoomed-in photograph of the top of the stack system containing the AOI-4 exclusion area.

IMG_0043: Northern view of the side slope from the drilling pad

IMG_0050: The top of the stack system containing the AOI-4 exclusion area.

From: Provenzano, Santino
To: Coates, John; Kautz, Lance; DWRMIW.PM
Cc: Wuitschick, Scott; Robert.Werner@mosaicco.com; Ford, Dara; Casey.Suarez@mosaicco.com; Adams, Bevan; Ward, Michael
Subject: FL0036421-023-Mosaic New Wales Concentrates Plant - AOI4 Confirmed Critical Condition
Date: Friday, December 15, 2023 1:34:00 PM
Attachments: image001.png
Confirmed Critical Condition at Area of Interest 4_Rev. 12-14-2023.PDF

Dear Mr. Coates:

Please see the attached letter report prepared on behalf of Mosaic by Ardaman.

As described in Ardaman's report, monitoring and investigation of AOI-4 continues. Mosaic will continue to provide daily reports to the Department regarding any seismic acoustic emissions (SAE's) detected and ongoing vibrating wire piezometer data collected in the vicinity of AOI-4 in accordance with the requirements of Condition VI.15 of the above referenced permit.

Should you have any questions regarding this report, please contact me.

Thank you,

Santino A. Provenzano | Sr. Director, Environmental – North America Operations
The Mosaic Company | 13830 Circa Crossing Dr. | Lithia, FL 33547
P: 813.500.6384 | | C: 813.781.1185 | F: 813.571.6911 | E: santino.provenzano@mosaicco.com

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

December 14, 2023
File Number: 22-13-0025E

Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Florida 33547

Attention: Mr. Santino Provenzano | Senior Director, Environmental

Subject: Confirmed Critical Condition at Area of Interest 4
New Wales Plant South Gypsum Stack (SGS), Phase II West-North Area
Mosaic Fertilizer, LLC, New Wales Facility, Polk County, Florida

Gentlemen:

Signature Acoustic Emissions (SAEs) from the passive seismic monitoring system installed at the New Wales South Gypsum Stack were detected since September 2022 with sufficient energy, recurrence and similar spatial positioning in the limestone formations underlying the South Gypsum Stack to identify an area of interest, designated AOI4, warranting investigation with exploratory boreholes. As shown on Figure 1, AOI4 is located at the Phase II-West North Area of the Phase I/II gypsum stack. One vertical and four inclined boreholes have been advanced in the vicinity of AOI4 into the gypsum stack to vertical depths between 175 and 210 feet, terminating 30 to 60 feet above the primary HDPE liner on the base of the stack. During advancement of inclined borehole AOI4-9R at 9:30 AM on December 13, a 50% loss of drilling fluid circulation occurred at an inclined depth of 271 feet below the stack surface corresponding to Elevation 198 feet (NGVD), about 73 feet above the expected elevation of the primary HDPE liner on the base of the stack. The partial loss of circulation continued to an inclined depth of 275 feet at which point a complete loss of drilling fluid circulation occurred at 10:30 AM on December 13. Three-inch and 7-inch deep no resistance zones were then encountered at inclined depths of 281 and 284 feet, respectively. Drilling operation was suspended to incorporate necessary engineering safety controls when pressurized gas was detected at an inclined depth of 285 feet, corresponding to Elevation 187 feet (NGVD), about 62 feet above the expected elevation of the primary HDPE liner on the base of the stack. The borehole was then advanced to 290 feet with a complete loss of drilling fluid circulation advancing through what appears to be a void in gypsum in the lower 5 feet of the borehole, between corresponding elevations of 187 to 184 feet (NGVD). These conditions are indicative of a breach in the primary HDPE liner on the base of the stack caused by an anomaly in the underlying foundation and constitute a critical condition in accordance with Florida Department of Environmental Protection Chapter 62-672.770(6)(e), F.A.C.

In response to the reported SAEs at AOI4, process water in the Phase II West-North Area Settling Compartment was removed by January 2023 and stored in other onsite compartments. Based on the findings from the exploratory boreholes to-date, the following recommendations are provided.

- Keep the Phase II West-North Area Settling Compartment dewatered.

- Continue inspecting and monitoring the three underdrains (A, B and C) that were installed above the primary HDPE liner and the two underdrains (E and F) that were installed above the intermediate HDPE liner of the Phase II West-North Area.

- Continue the investigation of AOI4 to determine the extent and configuration of the cavity in gypsum at the base of the stack and anomaly in the underlying foundation. The investigation will include advancement of additional inclined and vertical boreholes, installation of vibrating wire piezometers and installation of collapse monitors. The feasibility of performing a microgravity survey from the surface of the stack at AOI4 using a remote microgravity equipment is currently being evaluated.

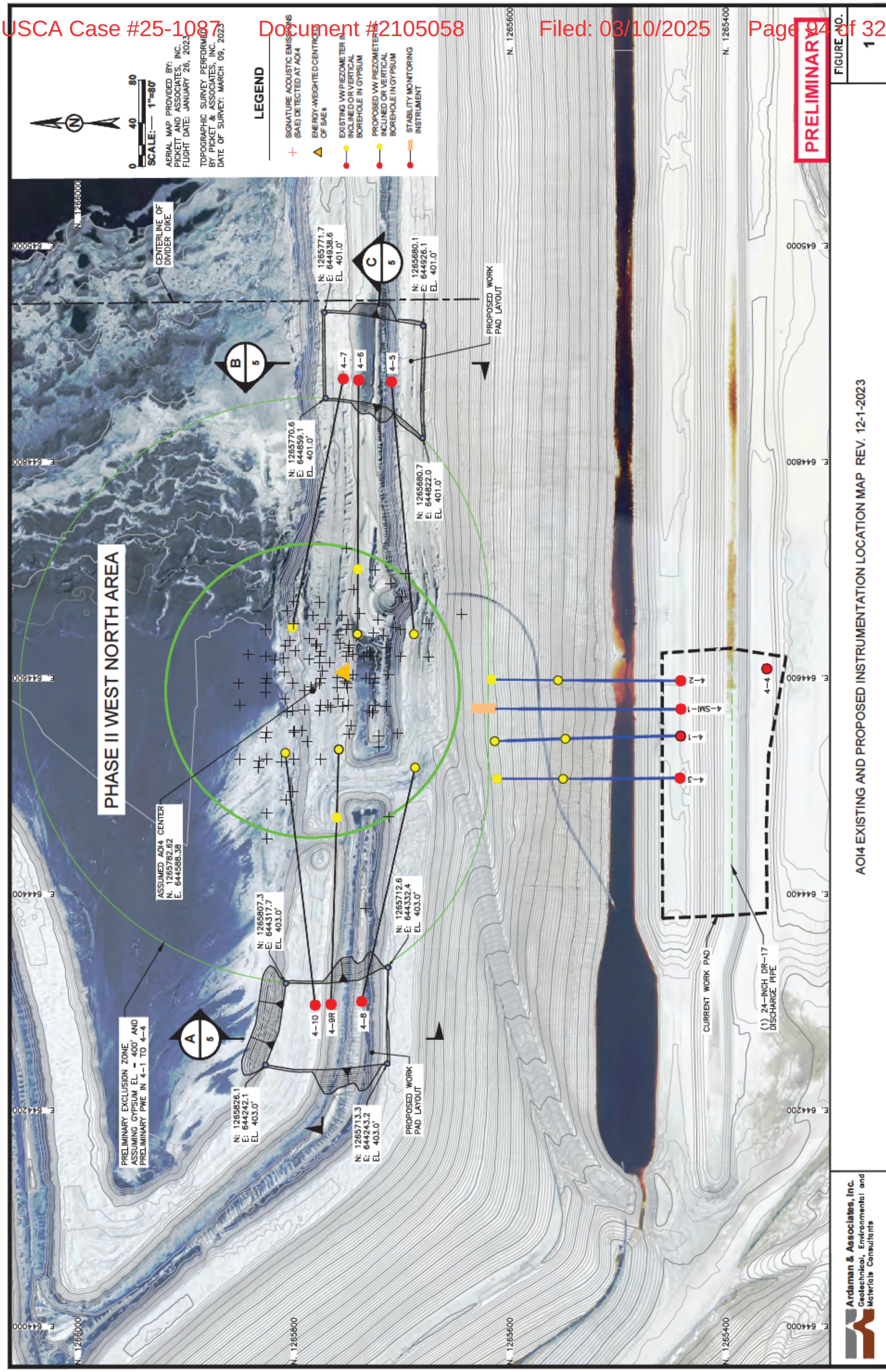
Please contact the undersigned if you have any questions.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.
Certificate of Authorization No. 5950

12/14/2023

Mohamad Al-hawaree, P.E.
President, Senior Consultant
Florida License No. 58537

cc: Patrick Kane – Mosaic
Patrick van der Voorn – Mosaic
Scott Wuitschick, P.E. – Mosaic
Robert Werner, P.E. – Mosaic
Casey Suarez – Mosaic
Peter Dominguez – Mosaic
Thomas Ingra, P.E. - Ardaman
Rajendra Shrestha, P.E. - Ardaman


AOI4 EXISTING AND PROPOSED INSTRUMENTATION LOCATION MAP REV. 12-1-2023
PRELIMINARY
FIGURE NO.
1
LEGEND
SIGNATURE ACOUSTIC EMISSIONS (SAE) DETECTED AT AOI4
ENERGY-WEIGHTED CENTROID OF SAEs
EXISTING VW PIEZOMETER IN INCLINED OR VERTICAL BOREHOLE IN GYPSUM
PROPOSED VW PIEZOMETER IN INCLINED OR VERTICAL BOREHOLE IN GYPSUM
STABILITY MONITORING INSTRUMENT
SCALE: 1"=80'
AERIAL MAP PROVIDED BY: PICKETT AND ASSOCIATES, INC. FLIGHT DATE: JANUARY 26, 2023
TOPOGRAPHIC SURVEY PERFORMED BY PICKET & ASSOCIATES, INC. DATE OF SURVEY: MARCH 09, 2023
PHASE II WEST NORTH AREA
CENTERLINE OF DIVIDER DIKE
ASSUMED AOI4 CENTER N: 1265782.62 E: 644588.38
PRELIMINARY EXCLUSION ZONE ASSUMING GYPSUM EL. ~ 400' AND PRELIMINARY PWE IN 4-1 TO 4-4
PROPOSED WORK PAD LAYOUT
CURRENT WORK PAD
(1) 24-INCH DR-17 DISCHARGE PIPE
N: 1265771.7 E: 644938.6 EL. 401.0'
N: 1265680.1 E: 644926.1 EL. 401.0'
N: 1265770.6 E: 644859.1 EL. 401.0'
N: 1265680.7 E: 644822.0 EL. 401.0'
N: 1265807.3 E: 644317.7 EL. 403.0'
N: 1265712.6 E: 644332.4 EL. 403.0'
N: 1265826.1 E: 644242.1 EL. 403.0'
N: 1265713.3 E: 644243.2 EL. 403.0'
4-7
4-6
4-5
4-10
4-9R
4-8
4-2
4-SMI-1
4-1
4-3
4-4
Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants

PUBLIC NOTICE
LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY (LDEQ)
MOSAIC FERTILIZER LLC - UNCLE SAM PLANT
GYPSUM MANAGEMENT AREA AND APPURTENANCES
PUBLIC HEARING AND REQUEST FOR PUBLIC COMMENT ON A DRAFT SOLID WASTE PERMIT RENEWAL & THE ASSOCIATED ENVIRONMENTAL ASSESSMENT STATEMENT (EAS)

The LDEQ, Office of Environmental Services, will conduct a public hearing to receive comments on a Draft Solid Waste Permit Renewal Application and The Associated Environmental Assessment Statement (EAS) for Mosaic Fertilizer LLC, 7250 Highway 44, Uncle Sam, LA 70792 for the Uncle Sam Plant - Gypsum Management Area and Appurtenances. **The facility is located at 7250 Highway 44, Uncle Sam, in St. James Parish.**

The hearing will be held on **Thursday, March 7, 2024 beginning at 6:00 p.m., at the St. James Parish Courthouse, Council Chambers, 5800 Louisiana Highway 44, Convent, LA 70723.** The hearing will be held in accordance with CDC guidance and in compliance with any guidelines issued by the Governor's office. During the hearing, all interested persons will have an opportunity to present oral statements, views, recommendations, opinions and information on the proposed permit. Additionally, written statements and other documents such as charts, data, and tabulations may be filed with the hearing officer at the hearing.

Mosaic Fertilizer LLC proposes to continue to operate an existing Type I Industrial Landfill (Gypsum Stacks 1 to 4) and Type I Industrial Surface Impoundments (30-Acre Active Reservoir, 110-Acre Reservoir, Active Return Ditch, Active Water Return Flume, and 04 Basin), collectively known as the Gypsum Management Area and Appurtenances. Mosaic also proposes to modify the Gypsum Management Area by constructing an expansion known as Stack 5A, thereby increasing the capacity of the facility. Gypsum Stacks 1 to 5 will be used to dispose up to 135,000 wet tons per week and 7,020,000 wet tons per year of industrial waste generated by the facility. The 30-Acre Active Reservoir, 110-Acre Reservoir, Active Return Ditch, Active Water Return Flume, and 04 Basin are not designed as disposal units and are used to transport active water from Gypsum Stacks 1 to 5 to the plant production area or, in the case of the 110-Acre Reservoir, as a stormwater collection pond and an emergency diversion impoundment.

The EAS submitted by the applicant addresses avoidance of potential and real environmental effects, balancing of social and economic benefits against environmental impact costs, and alternative sites, projects, and mitigative measures.

The public hearing will be conducted in accordance with La. R.S. 30:2017, which addresses the authority of the hearing officer, provides for the order in which speakers will be allowed to speak. A hearing officer will preside over the public hearing. This will be a formal hearing for the purpose of gathering facts and information. It will not include a "question and answer" component. In accordance with La. R.S. 30:2016, the hearing will be transcribed and become a part of the official public record.

Comments and requests for a public hearing or notification of the final decision can be submitted online on the public notice webpage (http://www.deq.louisiana.gov/public-notices), via personal delivery, or U.S. mail. **Comments and requests for public hearings must be received by 4:30 pm CST, Monday, April 8, 2024.** Delivery may be made to the drop-box at 602 N. 5th St., Baton Rouge, LA 70802. U.S. Mail may be sent to LDEQ, Public Participation Group, P.O. Box 4313, Baton Rouge, LA 70821-4313, and emails may be submitted to DEQ.PUBLICNOTICES@LA.GOV. Persons wishing to receive notice of the final permit action must include a complete mailing address when submitting comments.

Please see additional instructions for comment submission, hand delivery and information regarding electronic submission at http://www.deq.louisiana.gov/page/the-public-participation-group or call (225) 219-3276.

A written response to all public comments will be prepared at the time of the final permit decision. LDEQ will send notification of the final permit decision to the applicant and to each person who has submitted written comments or a written request for notification of the final decision.

The draft solid waste renewal permit, EAS, and technically complete solid waste permit application are available for review at the LDEQ, Public Records Center, 602 North 5th Street, Baton Rouge, LA. Viewing hours are from 8:00 a.m. to

4:30 p.m., Monday through Friday (except holidays). **The available information can also be accessed electronically on the Electronic Document Management System (EDMS) on the DEQ public website at www.deq.louisiana.gov**.

Additional copies may be reviewed at the Capital Regional Office, 602 N. 5th Street, Baton Rouge, LA 70802; St. James Parish Council, 5800 Highway 44, Convent, LA 70723; and St. James Parish Library - Lutcher – Headquarters, 1879 W Main St., Lutcher, LA 70071-9704.

Individuals with a disability, who need an accommodation in order to participate in the public hearing, should contact Denise Roderick via US mail at LDEQ, Public Participation Group, P.O. Box 4313, Baton Rouge, LA 70821-4313, email at DEQ.PUBLICNOTICES@LA.GOV, or phone at (225) 219-3376.

Inquiries or requests for additional information regarding this permit action should be directed to Mr. Stan Hazard, LDEQ, Waste Permits Division, P.O. Box 4313, Baton Rouge, LA 70821-4313, phone (225) 219-3103.

Persons wishing to be included on the LDEQ permit public notice mailing list, wishing to receive the permit public notices via email by subscribing to the LDEQ permits public notice List Server, or for other public participation related questions should contact the Public Participation Group in writing at LDEQ, P.O. Box 4313, Baton Rouge, LA 70821-4313, by email at DEQ.PUBLICNOTICES@LA.GOV or contact the LDEQ Customer Service Center at (225) 219-LDEQ (219-5337).

Permit public notices including electronic access to general information from the draft solid waste renewal permit application can be viewed at the LDEQ permits public notice webpage at http://www.deq.louisiana.gov/public-notices and general information related to the public participation in permitting activities can be viewed at http://www.deq.louisiana.gov/page/the-public-participation-group.

All correspondence should specify AI Number 2532, Permit Number P-0103-R1-M12, and Activity Number PER20210017.

Scheduled Publication Date: Thursday, February 15, 2024 (Advocate and News Examiner-Enterprise)

ENVIRONMENTAL PROTECTION AGENCY

[FRL–12519–01–OA]

Meeting of the Local Government Advisory Committee

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notification of public meeting.

SUMMARY: Pursuant to the Federal Advisory Committee Act (FACA), the EPA hereby provides notice of a meeting of the Local Government Advisory Committee (LGAC) on the date and time described below. This meeting will be open to the public. For information on public attendance and participation, please see the registration information under **SUPPLEMENTARY INFORMATION**.

DATES: The LGAC will have a virtual meeting January 9th, from 2–3 p.m. Eastern Standard Time.

FOR FURTHER INFORMATION CONTACT: Frank Sylvester, Designated Federal Officer (DFO) of the Local Government Advisory Committee, at *sylvester.frank.j@epa.gov* or 202–564–1279.

Information on Accessibility: For information on access or services for individuals requiring accessibility accommodations, please send an email to *LGAC@epa.gov*. To request accommodation, please do so five (5) business days prior to the meeting, to give EPA as much time as possible to process your request.

SUPPLEMENTARY INFORMATION:

Content: The LGAC will discuss a welcome letter to the incoming administration, highlighting the committee's value to the Agency and where the committee can best help the Administration achieve its priorities. Meeting materials and recommendations will be posted online closer to the meeting dates.

Registration: Both meetings will be held virtually through Microsoft Teams. Members of the public who wish to participate should register by contacting Frank Sylvester, Designated Federal Officer (DFO) of the Local Government Advisory Committee, at *sylvester.frank.j@epa.gov* or 202–564–1279 at least 24 hours of the meeting start time. The agenda and other supportive meeting materials will be available online at *https://www.epa.gov/ocir*/local-government-advisory-committee-lgac and can be obtained by written request to the DFO. In the event of cancellation for unforeseen circumstances, please contact the DFO or check the website above for reschedule information.

Francis Sylvester,

Designated Federal Officer, Office of Congressional and Intergovernmental Relations.

[FR Doc. 2024–30752 Filed 12–20–24; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[EPA–HQ–OAR–2024–0446; FRL–12501–01–OAR]

Notice of Approval for Other Use of Phosphogypsum

AGENCY: Office of Air and Radiation, Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: The Environmental Protection Agency (the EPA or the Agency) has approved, subject to certain conditions, the request for a "Small-scale Road Pilot Project on Private Land in Florida" submitted by Mosaic Fertilizer, LLC in March 2022, and updated by the "Revised Request for Approval of Use of Phosphogypsum in Small-scale Pilot Project", submitted in August 2023. The Agency's review found that Mosaic's request is complete per the requirements of EPA's National Emissions Standards for Hazardous Air Pollutants under the Clean Air Act, and that the potential radiological risks from conducting the pilot project meet the regulatory requirement that the project is at least as protective of public health as maintaining the phosphogypsum in a stack. On October 9, 2024, the EPA issued a pending approval of the request and solicited public comments on the pending approval. While EPA received comments raising questions about the project, no comments were received which led EPA to change the results of its risk analyses for this proposed pilot project. This approval is only for the proposed pilot project, and EPA has placed conditions on the approval to make sure that the project remains within the scope of the application.

DATES: This decision is effective immediately.

FOR FURTHER INFORMATION CONTACT: Jonathan Walsh, Radiation Protection Division, Office of Radiation and Indoor Air, Mail Code 6608T, Environmental Protection Agency, 1200 Pennsylvania Avenue NW, Washington, DC 20460; 202–343–9238; *Walsh.Jonathan@epa.gov*.

SUPPLEMENTARY INFORMATION:

I. Background

Phosphogypsum is the waste byproduct of wet acid phosphorous production. It contains elevated concentrations of the radionuclide radium, which decays to form radon gas. The EPA's regulations under the Clean Air Act at 40 CFR part 61, subpart R (hereafter "Subpart R") require that phosphogypsum must be disposed of in engineered piles, called stacks, to limit public exposure to its radioactive components. Subpart R allows the removal of phosphogypsum from stacks for outdoor agricultural purposes and indoor research and development, subject to conditions and restrictions. Any other use of phosphogypsum requires prior approval from the EPA. The EPA may approve a request for a specific use of phosphogypsum if it determines that the proposed use is at least as protective of public health as placement of phosphogypsum in a stack. The processes for requesting such an approval are described in 40 CFR 61.206.

Mosaic Fertilizer, LLC submitted a request for a Small-scale Road Pilot Project on Private Land in Florida in March 2022, and submitted a Revised Request for Approval of Use of Phosphogypsum in Small-scale Pilot Project in August 2023. Mosaic has proposed to construct a small-scale pilot project at its New Wales facility in Polk County, Florida. Mosaic's plan is to construct four sections of test road having varying mixtures of phosphogypsum (PG) in the road base "to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge construction" (Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 CFR 61.206, Small-scale Road Pilot Project on Private Land in Florida). The pilot project will be constructed in the place of an existing facility road near the phosphogypsum stack, and the study will be conducted in conjunction with researchers from the University of Florida.

The EPA performed a complete review of Mosaic's request, documented in "Review of the Small-scale Road Pilot Project on Private Land in Florida Submitted by Mosaic Fertilizer, LLC" (*www.regulations.gov*, Docket ID No. EPA–HQ–OAR–2024–0446). The Agency's review found that Mosaic's request is complete per the requirements of 40 CFR 61.206(b). Further, the review found that Mosaic's risk assessment is technically acceptable, and that the potential radiological risks from the proposed

project meet the regulatory requirements of 40 CFR 61.206(c); that is, the project is at least as protective of public health as maintaining the phosphogypsum in a stack. Therefore, the Agency issued an approval of the small-scale pilot project per 40 CFR 61.206, subject to terms and conditions which limit the project to the scope of the application. The terms and conditions are included in the approval letter to Mosaic, which is available in the public docket and on the EPA website, *https://www.epa.gov/radiation/phosphogypsum.* Approval by the Agency is specific to the pilot project as described in the Mosaic request and indicates only that this project meets the approval requirements of Subpart R.

II. Public Comments and Responses

The EPA's decision to approve or deny a request for other use under 40 CFR 61.206 is not a rulemaking. In December 2005, the EPA issued a guidance document, ''Applying to EPA for Approval of Other Uses of Phosphogypsum: Preparing and Submitting a Complete Petition Under 40 CFR 61.206, A Workbook'' (December 2005). Although this guidance is not binding, the EPA sought public comment on this pending approval using the procedure described in Section 2.4 of the Workbook. As outlined in the Workbook, the EPA published a notice of availability of this pending approval in the **Federal Register** on October 9, 2024, and opened a 30-day comment period, which was extended in response to public requests for an additional 15 days to close on November 23, 2024. Physical copies of the Mosaic request and the EPA's technical evaluation were placed for public review in the Mulberry Public Library, 905 NE 5th Street, Mulberry, FL 33860. The EPA also placed notices of public availability in local newspapers.

The EPA has reviewed all comments received for their relevance to the pending approval.

Many comments requested an extension of the 30-day comment period. The EPA extended the comment period in response to these requests.

The majority of comments were generally opposed to the use of phosphogypsum in public roads, and critical of the current state of phosphogypsum management; these comments were determined to be outside the scope of this action, which is specific to the small-scale pilot project as it is described in Mosaic's request. The EPA's approval applies only to the proposed pilot project and not any broader use. Any other use would require a separate application, risk assessment, and approval.

Comments related to EPA's management of phosphogypsum and its non-radiological contaminants under the Resource Conservation and Recovery Act and other statutes similarly fell outside the scope of the current decision. EPA has documented other regulatory issues in its supporting documents, but EPA's decision is only a determination of the permissibility of the project under the Clean Air Act National Emissions Standards for Hazardous Air Pollutants for Radionuclides. It does not imply any other regulatory approval or determinations of compliance. These must be obtained or made separately from this decision.

Some commenters indicated that EPA established a legal ban on the use of phosphogypsum in road construction by considering but not issuing a categorical approval in 1992. Road use is not prohibited by the regulation as amended in 1992 and is eligible to be considered as an ''other use.''

Commenters were critical of many aspects of the risk assessment. Commenters questioned the EPA's overall ability to perform radiological risk assessment, use of fatal radiogenic cancers as a health endpoint, selection of dose and risk coefficients, selection of models, and selection of exposure scenarios and whether current risk data was used. Specifically, several commenters believed that greater emphasis should be placed on the consideration of a future resident at the site of the pilot project. These comments represent disagreements with decisions that EPA has made in its evaluation of potential risks associated with the proposed pilot project, rather than new information that the Agency has not previously considered. After reviewing the comments, the EPA continues to believe that the risk assessments associated with this pilot project are consistent with current radiological risk assessment methodologies and precedent, and sufficient to evaluate the project per the requirements of 40 CFR 61.206. Results from multiple modeling efforts indicate that risks due to the proposed pilot project are low. EPA believes that for this existing site, it is most appropriate to consider the potential risk to site workers and the nearest residents to the site when determining whether the pilot project is as protective as leaving the phosphogypsum in the stack. No comments raised topics which EPA did not consider in its technical evaluation or lead to a concern for human health or environmental impacts not previously considered.

The Agency's response to comments document is available in the public docket[1] and on the EPA phosphogypsum website,[2] together with electronic copies of the application, the EPA's review, and relevant background materials.

Joseph Goffman,

Assistant Administrator, Office of Air and Radiation.

[FR Doc. 2024–30508 Filed 12–20–24; 8:45 am]

BILLING CODE 6560–50–P

FEDERAL COMMUNICATIONS COMMISSION

[OMB 3060–1155; FR ID 269133]

Information Collection Being Reviewed by the Federal Communications Commission

AGENCY: Federal Communications Commission.

ACTION: Notice and request for comments.

SUMMARY: As part of its continuing effort to reduce paperwork burdens, and as required by the Paperwork Reduction Act (PRA) of 1995, the Federal Communications Commission (FCC or the Commission) invites the general public and other Federal agencies to take this opportunity to comment on the following information collection. Comments are requested concerning: whether the proposed collection of information is necessary for the proper performance of the functions of the Commission, including whether the information shall have practical utility; the accuracy of the Commission's burden estimate; ways to enhance the quality, utility, and clarity of the information collected; ways to minimize the burden of the collection of information on the respondents, including the use of automated collection techniques or other forms of information technology; and ways to further reduce the information collection burden on small business concerns with fewer than 25 employees.

DATES: Written PRA comments should be submitted on or before February 21, 2025. If you anticipate that you will be submitting comments, but find it difficult to do so within the period of time allowed by this notice, you should advise the contact listed below as soon as possible.

[1] *https://www.regulations.gov,* Docket ID No. EPA–HQ–OAR–2024–0446.

[2] *https://www.epa.gov/radiation/phosphogypsum#aaup.*

please contact FERC Online Support at *FERCOnlineSupport@ferc.gov,* (866) 208–3676 (toll free), or (202) 502–8659 (TTY).

In lieu of electronic filing, you may submit a paper copy. Submissions sent via U.S. Postal Service must be addressed to, Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission, 888 First Street NE, Room 1A, Washington, DC 20426. Submissions sent via any other carrier must be addressed to, Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission, 12225 Wilkins Avenue, Rockville, Maryland 20852. The first page of any filing should include docket number P–13417–008. Comments emailed to Commission staff are not considered part of the Commission record.

In addition to publishing the full text of this document in the **Federal Register**, the Commission provides all interested persons an opportunity to view and/or print the contents of this document via the internet through the Commission's Home Page (*http://ferc.gov*) using the ''eLibrary'' link. Enter the docket number excluding the last three digits in the docket number field to access the document. At this time, the Commission has suspended access to the Commission's Public Reference Room, due to the proclamation declaring a National Emergency concerning the Novel Coronavirus Disease (COVID–19), issued by the President on March 13, 2020. For assistance, contact the Federal Energy Regulatory Commission at *FERCOnlineSupport@ferc.gov* or call toll-free, (886) 208–3676 or TYY, (202) 502–8659.

Dated: October 14, 2020.

Kimberly D. Bose,

Secretary.

[FR Doc. 2020–23158 Filed 10–19–20; 8:45 am]

BILLING CODE 6717–01–P

DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

Combined Notice of Filings

Take notice that the Commission has received the following Natural Gas Pipeline Rate and Refund Report filings:

Docket Number: PR20–70–001.
Applicants: Regency Intrastate Gas LP.
Description: Tariff filing per 284.123(b),(e)/: Revised Operating Statement to be effective 6/2/2020.
Filed Date: 10/13/2020.
Accession Number: 202010135157.
Comments/Protests Due: 5 p.m. ET 11/3/2020.

Docket Numbers: RP20–1229–001.
Applicants: Cheniere Corpus Christi Pipeline, LP.
Description: Tariff Amendment: Housekeeping Supplemental Filing to be effective 10/28/2020.
Filed Date: 10/13/20.
Accession Number: 20201013–5193.
Comments Due: 5 p.m. ET 10/26/20.

Docket Numbers: RP21–53–000.
Applicants: Panhandle Eastern Pipe Line Company, LP.
Description: § 4(d) Rate Filing: Housekeeping Filing on 10–13–20 to be effective 11/13/2020.
Filed Date: 10/13/20.
Accession Number: 20201013–5151.
Comments Due: 5 p.m. ET 10/26/20.

Docket Numbers: RP21–54–000.
Applicants: El Paso Natural Gas Company, L.L.C.
Description: § 4(d) Rate Filing: Non-Conforming Agreements Update (NMG) to be effective 1/1/2021.
Filed Date: 10/13/20.
Accession Number: 20201013–5165.
Comments Due: 5 p.m. ET 10/26/20.

The filings are accessible in the Commission's eLibrary system (*https://elibrary.ferc.gov/idmws/search/fercgensearch.asp*) by querying the docket number.

Any person desiring to intervene or protest in any of the above proceedings must file in accordance with Rules 211 and 214 of the Commission's Regulations (18 CFR 385.211 and 385.214) on or before 5:00 p.m. Eastern time on the specified comment date. Protests may be considered, but intervention is necessary to become a party to the proceeding.

eFiling is encouraged. More detailed information relating to filing requirements, interventions, protests, service, and qualifying facilities filings can be found at: *http://www.ferc.gov/docs-filing/efiling/filing-req.pdf.* For other information, call (866) 208–3676 (toll free). For TTY, call (202) 502–8659.

Dated: October 14, 2020.

Nathaniel J. Davis, Sr.,

Deputy Secretary.

[FR Doc. 2020–23205 Filed 10–19–20; 8:45 am]

BILLING CODE 6717–01–P

ENVIRONMENTAL PROTECTION AGENCY

[FRL–10015–95–Region 1]

2020 Annual Meeting of the Ozone Transport Commission

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice; meeting.

SUMMARY: The United States Environmental Protection Agency (EPA) is announcing the 2020 Annual Meeting of the Ozone Transport Commission (OTC). The meeting agenda will include topics regarding reducing ground-level ozone precursors.

DATES: The meeting will be held on November 18, 2020 starting at 9 a.m. and ending at noon.

ADDRESSES: Virtual meeting. Further information on the details for the virtual public meeting will be available at *http://www.otcair.org.*

FOR FURTHER INFORMATION CONTACT:

For documents and press inquiries contact: Ozone Transport Commission, 89 South St., Suite 602, Boston, MA 02111; (617) 259–2005; email: *ozone@otcair.org*; website: *http://www.otcair.org.*

For registration: To register for the virtual meeting, please use the online registration form available at *http://www.otcair.org,* or contact the OTC at (617) 259–2005 or by email at *ozone@otcair.org.*

SUPPLEMENTARY INFORMATION: The Clean Air Act Amendments of 1990 contain Section 184 provisions for the Control of Interstate Ozone Air Pollution. Section 184(a) establishes an Ozone Transport Region (OTR) comprised of the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, parts of Virginia and the District of Columbia. The purpose of the OTC is to address ground-level ozone formation, transport, and control within the OTR.

Type of Meeting: Open.

Agenda: Copies of the final agenda will be available from the OTC office (617) 259–2005; by email: *ozone@otcair.org* or via the OTC website at *http://www.otcair.org.*

Dated: October 14, 2020.

Dennis Deziel,

Regional Administrator, EPA Region 1.

[FR Doc. 2020–23122 Filed 10–19–20; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[EPA–HQ–OAR–2020–0442; FRL–10014–36–OAR]

Approval of the Request for Other Use of Phosphogypsum by the Fertilizer Institute

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: The Environmental Protection Agency (EPA) is approving, subject to certain conditions, a request by The Fertilizer Institute for use of phosphogypsum in government road projects. This decision and supporting information is being made available to the public through this notice. Under the Clean Air Act, the EPA may approve a request for other use of phosphogypsum if it determines that the proposed use is at least as protective of human health as placement in a stack, which is the designated management method. With this approval, and in accordance with its terms and conditions, government entities may use phosphogypsum for road construction projects.

DATES: October 20, 2020.

FOR FURTHER INFORMATION CONTACT: Jonathan P. Walsh, Radiation Protection Division, Office of Radiation and Indoor Air, Mail Code 6608T, Environmental Protection Agency, 1200 Pennsylvania Ave. NW, Washington, DC 20460; telephone number: (202) 343–9238; fax number: (202) 343–2304; email address: *walsh.jonathan@epa.gov.*

Organization of this document. The information in this notice is organized as follows:

SUPPLEMENTARY INFORMATION:

I. General Information

A. How can I get copies of this document and other related information?

1. *Docket.* The EPA has established a docket for this action under Docket ID No. EPA–HQ–OAR–2020–0442. Publicly available docket materials are available either electronically through *www.regulations.gov* or in hard copy at the Air and Radiation Docket in the EPA Docket Center, (EPA/DC) EPA West, Room 3334, 1301 Constitution Ave. NW, Washington, DC. The EPA Docket Center Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air and Radiation Docket is (202) 566–1742.

2. *Electronic Access.* You may access this **Federal Register** document electronically from the Government Printing Office under the ''**Federal Register**'' listings at FDSys (*http://www.gpo.gov/fdsys/browse/collection.action?collectionCode=FR*).

II. Background and Overview of Decision

Phosphogypsum stacks are large piles of waste from wet acid phosphorous production. There are more than 60 stacks of phosphogypsum located in 13 different states. The majority of these stacks are located in the southeastern region of the United States. Because the phosphate ore used to produce the phosphoric acid contains relatively high concentrations of uranium and radium, phosphogypsum stacks also contain high concentrations of these elements. The presence of radium in the stacks causes them to release radon gas into the atmosphere.

The EPA regulates the management of phosphogypsum based on its elevated levels of radium and its decay products, including radon gas, which is classified as a hazardous air pollutant under the Clean Air Act. As required by 40 CFR part 61, subpart R (hereafter ''Subpart R''), phosphogypsum must be disposed of in engineered piles, called stacks, with the exception of limited use for agricultural and research purposes. In addition, applicants may request approval of other uses of phosphogypsum by following the process prescribed in 40 CFR 61.206.

A. The EPA's 1992 Risk Assessment

The EPA initially established the requirement that phosphogypsum be placed into stacks without any exceptions (54 FR 51674, December 15, 1989). In response to petitions for reconsideration, the EPA re-evaluated the risks of selected applications of phosphogypsum against the risks from stacking (57 FR 23305, June 3, 1992).[1] The EPA determined that the use of phosphogypsum in limited agricultural and indoor research activities could be as protective of human health, in the short- and long-term, as stacking. These approved uses were incorporated into Subpart R at 40 CFR 61.204–205.

The EPA also assessed the use of phosphogypsum in road construction. While the risks were found to be acceptable from most of the exposure scenarios analyzed, the potential risks to residents of dwellings constructed on an abandoned road were calculated to be unacceptably high. The EPA therefore did not approve road construction as a categorical use of phosphogypsum. The EPA did, however, define in 40 CFR 61.206 a process to request approval of other uses of phosphogypsum, including a risk assessment demonstrating that the proposed use is at least as protective of human health, in the short- and long-term, as placement in a stack. As stated in the preamble to the final rule, the measure of protectiveness is lifetime risk of fatal cancer to individuals. In connection with the removal of phosphogypsum from stacks for authorized uses, the EPA incorporated sampling, certification, and record-keeping requirements into Subpart R at 40 CFR 61.207 through 61.209.

B. Request by The Fertilizer Institute

On October 15, 2019, The Fertilizer Institute (TFI) submitted its initial ''Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 CFR 61.206,'' requesting that EPA approve the use of phosphogypsum in road construction. Subsequently, on April 7, 2020, TFI submitted, on behalf of its members that own or operate phosphogypsum stacks, a revised request: ''Revised Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 CFR 61.206: Use in Road Construction Projects Authorized by Federal, State and Local Departments of Transportation or Public Works.''

TFI requested that phosphogypsum be approved specifically for government road projects authorized by federal, state and local Departments of Transportation (DOT) or Public Works (PW), and conducted as part of a government road project using appropriate, generally accepted road construction standards and specifications such as ASTM,[2] Federal Highway Administration, federal or state DOT standards and specifications, or standards developed or approved in consultation with the appropriate regulatory DOT or PW authorities. Notably, as envisioned by the request, the submitter of the request (TFI) would not be the entity using the phosphogypsum, although its members may supply the phosphogypsum to the end user (*i.e.,* the government agency responsible for the road construction project). To address this situation, the terms and conditions of the approval require that the phosphogypsum supplier (stack owner or operator) and the end user each provide information to the EPA, as appropriate, prior to removal of phosphogypsum from the stack.

TFI estimates that the cost of transportation would make the use of

[1] ''Potential Uses of Phosphogypsum and Associated Risks: Background Information Document,'' EPA 402–R92–002, May 1992.

[2] Formerly the American Society for Testing and Materials, now ASTM International.

phosphogypsum uneconomical at distances greater than about 200 miles from a stack.[3] In that case, the regional distribution of phosphogypsum stacks suggests that its use for road construction would likely be concentrated in the southeastern part of the country but could also occur in western states such as Idaho and Wyoming.

C. TFI's Risk Assessment

As required by Subpart R, TFI submitted a risk assessment as part of its request.[4] The risk assessment assessed potential exposures to individuals in various scenarios involving road users, nearby residents, and road construction workers. TFI's exposure scenarios and modeling approaches were largely consistent with the EPA's 1992 analysis, as were the overall results.

The EPA finds TFI's risk assessment to adequately demonstrate that the use of phosphogypsum in road construction will be at least as protective of human health, in the short- and long-term, as stacking.[5] However, as in 1992, the EPA remains concerned about potential exposures should the road become abandoned, particularly for a residence built on road material containing phosphogypsum. The EPA does not agree that TFI's assumptions in its analysis of this scenario, such as the use of radon resistant home construction techniques, could be relied upon to limit the potential risks to a future residential individual from such an occurrence. In this case, however, the EPA believes that this risk can be acceptably mitigated by including appropriate terms and conditions in the approval.

In defining its request and exposure scenarios, TFI's risk assessment assumes certain limitations involving the construction and placement of roads. For example, phosphogypsum incorporated into the road base and the road surface is limited in its radium-226 concentration and is assumed to be mixed with other materials in limited proportions. The terms and conditions of the approval reflect these assumptions and limitations.

D. Terms and Conditions of the Approval

The EPA has determined that, subject to the terms and conditions summarized below, phosphogypsum may be removed from stacks and used in government road projects, as requested by TFI. This approval to use phosphogypsum in road construction does not authorize the removal of any phosphogypsum from any stacks or the use of any phosphogypsum for road construction unless and until the information required by the ''Initial Conditions,'' below, is provided to EPA. Only after such information is provided to EPA, may phosphogypsum be removed from stacks and used in road construction, further provided that the conditions expressed in ''Other Conditions,'' below, continue to be met. A complete listing of the terms and conditions applicable to this approval may be found in the approval letter.[6] Additional supporting documentation, such as the complete TFI request and risk assessment, are also in the docket.

1. Initial Conditions

Prior to the distribution and/or use of phosphogypsum for any government road project, the owner or operator of the stack from which phosphogypsum is to be distributed or the governmental entity responsible for building and maintaining the road, as appropriate, must submit to the Agency all information required by 40 CFR 61.206(b), as more specifically described in the approval letter.

2. Other Conditions[7]

Subsequent to the provision of the initial required information to EPA, phosphogypsum may be used in government road projects in accordance with additional conditions, as stated in the approval letter, including, for example, conditions related to:

- Continued control, maintenance, and use of the road;
- Sampling, certification, and record-keeping requirements in 40 CFR 61.206(d) and 61.207 through 61.209;
- Construction of the road consistent with the assumptions, scenarios, limitations, and parameters analyzed in TFI's risk assessment, including an average radium content of no more than 35 pCi/g, no more than 2.25% PG by weight in surface pavement and no more than 50% PG by weight in the road base; and
- Notification and availability of information for the public and road construction workers on the use of phosphogypsum in the road project.

Any use of phosphogypsum not consistent with the terms and conditions and any other limitations set forth in this approval shall be construed as unauthorized distribution of phosphogypsum and may constitute a violation of or noncompliance with 40 CFR part 61, subpart R. This approval is pursuant to Subpart R promulgated under the authority of the Clean Air Act. This approval does not relieve TFI, phosphogypsum stack owners or operators or resellers, retailers, distributors, or end users or other entities handling, processing or using phosphogypsum of responsibility to comply with other applicable laws and regulations.

Andrew Wheeler,

Administrator.

[FR Doc. 2020–23154 Filed 10–19–20; 8:45 am]

BILLING CODE 6560–50–P

[3] ''Economic Analysis of Phosphogypsum Reuse,'' prepared for TFI by Policy Navigation Group, submitted as Appendix 6 to TFI's Revised Request, December 2019, page 19.

[4] ''Radiological Risk Assessment in Support of Petition for Beneficial Use of Phosphogypsum,'' prepared for TFI by Arcadis Canada Inc., submitted as Appendix 2 to TFI's Revised Request, October 2019.

[5] ''Review of the Radiological Risk Assessment Submitted in Support of Request for Approval of Other Use of Phosphogypsum,'' October 2019, The Fertilizer Institute.

[6] Letter from Andrew Wheeler, Administrator, Environmental Protection Agency, to Corey Rosenbusch, President and CEO, The Fertilizer Institute, Docket No. EPA–HQ–OAR–2020–0442.

[7] In addition to the information required by 40 CFR 61.206(b), as noted in connection with the ''Initial Conditions,'' the ''Other Conditions'' include conditions associated with the requirements of 40 CFR 61.206(d) and 61.207–61.209; conditions inherent in the nature of or limitations or assumptions associated with TFI's request; and conditions imposed under the EPA's authority and discretion under 40 CFR 61.206(e). The EPA believes that these conditions are either required by 40 CFR part 61, subpart R or are reasonably appropriate to help provide continued assurance that the use is at least as protective as disposal of phosphogypsum in stacks and will ensure that the removal of phosphogypsum from stacks and use in government road projects will be consistent with TFI's request and will occur with public notice and appropriate information availability.

ENVIRONMENTAL PROTECTION AGENCY

[EPA–HQ–OPPT–2020–0077; FRL–10015–81]

Certain New Chemicals; Receipt and Status Information for September 2020

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: EPA is required under the Toxic Substances Control Act (TSCA), as amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act, to make information publicly available and to publish information in the **Federal Register** pertaining to submissions under TSCA Section 5, including notice of receipt of a Premanufacture notice (PMN), Significant New Use Notice (SNUN) or Microbial Commercial Activity Notice (MCAN), including an amended notice or test information; an exemption

ENVIRONMENTAL PROTECTION AGENCY

[EPA–HQ–OAR–2020–0442; FRL–10024–70–OAR]

Withdrawal of Approval for Use of Phosphogypsum in Road Construction

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: The Environmental Protection Agency (EPA) is withdrawing its October 14, 2020 approval for use of phosphogypsum in government road projects. Under the Clean Air Act, the EPA may approve a request for other use of phosphogypsum if it includes certain prescribed information. Upon further review, EPA has determined that the approval was premature and should be withdrawn because the request did not contain all of the required information. With this action, phosphogypsum remains prohibited from use in road construction projects.

DATES: Effective July 7, 2021.

FOR FURTHER INFORMATION CONTACT: Jonathan P. Walsh, Radiation Protection Division, Office of Radiation and Indoor Air, Mail Code 6608T, Environmental Protection Agency, 1200 Pennsylvania Ave. NW, Washington, DC 20460; telephone number: (202) 343–9238; fax number: (202) 343–2304; email address: *walsh.jonathan@epa.gov.*

Organization of this document. The information in this notice is organized as follows:

I. General Information
II. Background and Overview of Decision

SUPPLEMENTARY INFORMATION:

I. General Information

A. How can I get copies of this document and other related information?

1. *Docket.* The EPA has established a docket for this action under Docket ID No. EPA–HQ–OAR–2020–0442. Publicly available docket materials are available either electronically through *www.regulations.gov* or in hard copy at the Air and Radiation Docket in the EPA Docket Center, (EPA/DC) EPA West, Room 3334, 1301 Constitution Ave. NW, Washington, DC. The EPA Docket Center Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air and Radiation Docket is (202) 566–1742.

2. *Electronic Access.* You may access this **Federal Register** document electronically from the Government Printing Office under the ''**Federal Register**'' listings at FDSys (*http://www.gpo.gov/fdsys/browse/collection.action?collectionCode=FR*).

II. Background and Overview of Decision

On October 14, 2020, EPA approved, subject to certain conditions, a request by The Fertilizer Institute (TFI) for the use of phosphogypsum in government road projects.[1] This request was submitted pursuant to Clean Air Act regulations at 40 CFR 61.206, which provide that EPA may approve request for a specific use of phosphogypsum if it is determined that the proposed use is at least as protective of public health as placement in a stack, which is the designated management method. EPA identified ten components that such a request ''must contain'' (40 CFR 61.206(b)). These include such items as the specific location where phosphogypsum will be used and the quantity of phosphogypsum to be used.

On December 18, 2020, various groups[2] petitioned the United States Court of Appeals for the District of Columbia Circuit for review of EPA's action conditionally approving TFI's request. On that same date, these same groups, ''as a precaution and as a matter of courtesy,'' submitted to EPA, ostensibly under Clean Air Act (CAA) § 307(d)(7)(B) (42 U.S.C. 7607(d)(7)(B)), a petition asking EPA to reconsider its action. EPA is further prompted to review this approval by Executive Order 13990, which directs agencies to examine a wide range of previously-issued actions in light of various policies and national objectives.[3]

EPA has the authority to review and reconsider, on its own initiative, previous decisions and actions. Upon further evaluation, EPA decides that it was premature for the Agency to approve the proposed use without all of the information specified as constituting a proper request under § 61.206(b). Therefore, EPA has withdrawn, revoked and rescinded the October 2020 approval.[4] This decision is without prejudice to a subsequent or further proper request under § 61.206 for approval of the use of phosphogypsum for other purposes that contains the information required by § 61.206(b). In accordance with the regulations at 40 CFR part 61, subpart R, unless and until any such request is approved, phosphogypsum must continue to be placed in stacks and may not be removed from stacks for use in road construction.

Michael S. Regan,
Administrator.

[FR Doc. 2021–14377 Filed 7–6–21; 8:45 am]

BILLING CODE 6560–50–P

[1] Letter from Andrew R. Wheeler, Administrator, Environmental Protection Agency, to Corey Rosenbusch, President and CEO, The Fertilizer Institute, dated October 14, 2020, Docket No. EPA–HQ–OAR–2020–0442–0015. See also 85 FR 66550, October 20, 2020.

[2] Center for Biological Diversity, Healthy Gulf, Manasota–88, Inc., North America's Building Trades Unions, People for Protecting Peace River, Inc., Public Employees for Environmental Responsibility, Rise St. James, and Sierra Club and its Florida chapter. See *Center for Biological Diversity* v. *EPA,* No. 20–1506.

[3] ''Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis,'' signed January 20, 2021. 86 FR 7037, January 25, 2021.

[4] Letter from Michael S. Regan, Administrator, Environmental Protection Agency, to Corey Rosenbusch, President and CEO, The Fertilizer Institute, Docket No. EPA–HQ–OAR–2020–0442. See this letter for further discussion of the reasons for the withdrawal, revocation, and recission of the prior October 2020 decision.

FEDERAL DEPOSIT INSURANCE CORPORATION

Notice to All Interested Parties of Intent To Terminate Receivership; Correction

In the notice the Federal Deposit Insurance Corporation (FDIC or Receiver) published in the April 27, 2021, **Federal Register** (86 FR 22204), Georgian Bank was incorrectly listed as Georgia Bank. This notice makes that correction.

Notice is hereby given that the FDIC as Receiver for the institution listed below intends to terminate its receivership for said institution.

Submitted via Electronic Mail

October 17, 2023

Ronald McCulley
Florida Department of Environmental Protection
2600 Blair Stone Road MS 3500
Tallahassee, Florida 32399

Mosaic Fertilizer, LLC - Riverview Facility
Initial Application to Construct Class I Injection Well System
Hillsborough County

Dear Mr. McCulley:

Please find attached herein an application for the Mosaic Fertilizer, LLC (Mosaic) Riverview Concentrate Facility (Facility) for construction of a proposed Class I Injection Well system. The proposed injection well system will be located at the Riverview facility located within Hillsborough County and will consist of two proposed injection wells and an associated dual-zone monitoring well. Included with this package is a signed and sealed copy of FDEP Form 62-528.900(1). Two checks in the amount of $12,500.00 will be mailed separately to the Department to support the associated permit processing fee for each proposed Class I injection well.

Mosaic has included the "Mosaic Riverview Concentrate Facility Class I Injection Well Construction Permit Application" which was prepared by our third-party consultant, Black & Veatch. This report provides the supporting information as required in the Florida Department of Environmental Protection (FDEP) Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems*.

If you have any questions or require any additional information to assist in the review of this application, please contact me at (813) 541.4633 or by email at ben.koplin@mosaicco.com.

Sincerely,

Ben L Koplin
Sr Manager, Environmental

Encl: FDEP Form 62-528.900(1)
Certificate of Officer – Mr. Scott Wuitschick
Mosaic Riverview Concentrate Facility Class I Injection Well Construction Permit Application

cc: John Coates, FDEP
Greg Howard, Mosaic
Pat Kane, Mosaic
Scott Wuitschick, Mosaic
Santino Provenzano, Mosaic
Dara Ford, Mosaic
Monica Tochor, Mosaic
Jackie Barron, Mosaic

MOSAIC RIVERVIEW CONCENTRATE FACILITY DEEP INJECTION WELLS NO. 1 AND NO. 2

Florida Department of Environmental Protection, Class I Injection Well Construction Permit Application

B&V PROJECT NO. 415475

PREPARED FOR

Mosaic Fertilizer, LLC

17 OCTOBER 2023

CERTIFICATIONS

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

PROFESSIONAL ENGINEER

The engineering features contained in the Class I, Municipal Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, October 2023, were prepared by, or reviewed by, a Licensed Professional Engineer in the State of Florida.

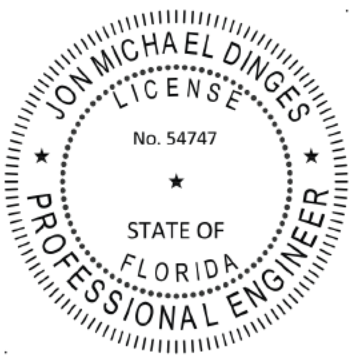
Jon Dinges, P.E.

10/17/2023

Date

PE54747

License No.



This item has been digitally signed and sealed by Jon M. Dinges on the date adjacent to the seal.
Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the Class I, Municipal Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, October 2023, were prepared by, or reviewed by, a Licensed Professional Geologist in the State of Florida.

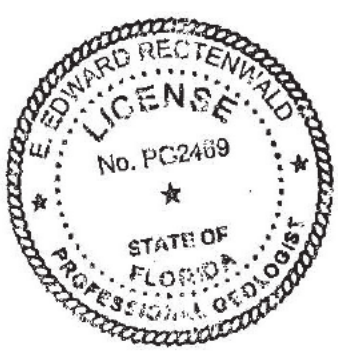
Ed Rectenwald, P.G.

10/17/2023

Date

PG2469

License No.



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LIST OF TABLES

LIST OF EXHIBITS

LIST OF ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ASR	Aquifer Storage and Recovery
AOR	Area of Review
APPZ	Avon Park permeable zone
ASTM	American Society for Testing and Materials
BHCS	Borehole Compensated Sonic Log
bls	below land surface
CAL	Caliper Log
CBL	Cement Bond Log
DIL	Dual Induction Log
DZMW	Dual-Zone Monitoring Well
EOR	Engineer of Record
FAS	Floridan Aquifer System
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FGS	Florida Geological Survey
FM	Flowmeter Log
FR	Fluid Resistivity Log
FRP	Fiberglass Reinforced Plastic
ft	Feet
feet/min	Feet per minute
feet/sec	Feet per second
gpm	Gallons per minute
HAC	Heat Pump/Air Conditioning
HRT	High Resolution Temperature Log
HVAC	Heating, Ventilation, and Air Conditioning
ICU	intermediate confining unit
ID	Inside diameter
IW	Injection Well
LFA	Lower Floridan aquifer
LMZ	Lower Monitoring Zone
MCU	Middle Confining Unit
MGD	Million gallons per day
mg/L	Milligrams per Liter
MIT	Mechanical Integrity Testing
NAVD	North American Vertical Datum
NELAP	National Environmental Laboratory Accreditation Program
NGR	Natural Gamma Ray Log
NGVD	National Geodetic Vertical Datum
OD	Outside diameter
P&A	Plugging and Abandonment
PMW	Pad Monitoring Well
psi	Pounds per Square Inch
PVC	Polyvinyl chloride
RO	Reverse Osmosis
RTS	Radioactive Tracer Survey

SAS	Surficial Aquifer System
SWFWMD	Southwest Florida Water Management District
SOP	Standard Operating Procedures
SP	Spontaneous Potential Log
TEMP	Temperature Log
TD	Total Depth
TDS	Total Dissolved Solids
TV	Video Survey
UFA	Upper Floridan aquifer
UIC	Underground Injection Control
UMZ	Upper Monitoring Zone
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
VDL	Variable Density Log
WRF	Water Reclamation Facility
WTP	Water Treatment Plant

Permit Application and Documentation Format

The information required in Florida Department of Environmental Protection (FDEP) Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems* is included herein and is divided into the following sections:

Section 1 - FDEP Form No. 62-528.900(1) Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems. The executed Class I Industrial Injection Well Construction Permit application is contained in this section and addresses the specific information requested in Application Form 62-528.900(1).

Section 2 - An introduction to the project that discusses well construction and testing is included in this section.

Section 3 - Supporting Documentation and Responses to Part A. Class I Injection Well Construction and Testing Permit. Section 3 includes Part A which is supporting documentation for the construction and testing of industrial injection wells (IW), IW-1 and IW-2, and dual-zone monitoring well (DZMW), DZMW-1.

Section 4 - Injection Well System Financial Assurance Documentation and Well Plugging Cost Estimates. The financial assurance documents and Engineer's opinion of cost for plugging and abandoning (P&A) based on the proposed designs of IW-1 and IW-2, and DZMW-1 is included in Section 4.

All project well schematics and figures are included in the Exhibits.

1.0 FDEP Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems

FDEP Rule No. 62- 528.900(1)] Forms for Underground Injection Control

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: .
DEP Application No,: .
WACS# (Filled in by DEP)

Florida Department of Environmental Protection

Twin Towers Office Bldg., 2600 Blair Stone Road, Tallahassee, Florida 32399-2400

APPLICATION TO CONSTRUCT/OPERATE/ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

Part I. Directions

A. All applicable items must be completed in full in order to avoid delay in processing this application. Where attached sheets or other technical documentation are utilized in lieu of the blank space provided, indicate appropriate cross-reference in the space and provide copies to the Department in accordance with C. below. Where certain items do not appear applicable to the project, indicate N/A in the appropriate spaces.

B. All information is to be typed or printed in ink.

C. Two (2) copies of this application and two (2) copies of supporting information such as plans, reports, drawings and other documents shall be submitted to the appropriate Department office if submitted as a paper document, or one (1) copy of the application and one (1) copy of the plans, reports, drawings and other documents if the submittal is in an electronic format. An engineering report is also required to be submitted to support this application pursuant to the applicable sections of Rule 62-528, F.A.C. The attached list* shall be used to determine completeness of supporting data submitted or previously received. A check for the application fee in accordance with Rule 62-4.050, F.A.C., made payable to the Department shall accompany the application.

D. For projects involving construction, this application is to be accompanied by two (2) sets or one (1) set, in accordance with C. above, of engineering drawings, specifications and design data as prepared by a Professional Engineer registered in Florida, where required by Chapter 471, Florida Statutes.

E. Attach 8 1/2" x 11" site location map indicating township, range and section and latitude/longitude for the project.

PART II. General Information

A. Applicant Name: Greg Howard Title: General Manager

Address: 13830 Circa Crossing Drive

City: Lithia State: FL Zip: 33547

Telephone Number: 863-255-7584 Email: greg.howard@mosaicco.com

B. Project Status: ☑ New ☐ Existing

☐ Modification (specify) N/A

*"Engineering and Hydrogeologic Data Required for Support of Application to Construct, Operate and Abandon Class I, III, or V Injection Wells"

C. Well Type: ☐ Exploratory Well ☑ Test/Injection Well

D. Type of Permit Application

- [x] Class I Test/Injection Well Construction and Testing Permit
- [ ] Class I Well Operation Permit
- [ ] Class I Well Operation Repermitting
- [ ] Class I Well Plugging and Abandonment Permit
- [ ] Class III Well Construction/Operation/Plugging and Abandonment Permit
- [ ] Class V Exploratory Well Construction and testing Permit
- [ ] Class V Well Construction Permit
- [ ] Class V Well Operation Permit
- [ ] Class V Well Plugging and Abandonment Permit
- [ ] Monitor Well Only

E. Facility Identification:

Name Mosaic Riverview Concentrate Facility

Facility Location: Street 8813 US Hwy 41 S

City Riverview County Hillsborough

SIC Code(s) 2874

F. Proposed facility located on Indian Lands: Yes ☐ No ☐

G. Well Identification:

Well No. IW-1 and IW-2 of 2 Wells *Multiple wells may be noted*
(total #)

See Permit App for Coordinates

Purpose (Proposed Use) Injection of Pre-Treated, non-hazardous Process Water from the Riverview Concentrate Facility

Well Location: Latitude: See ° Permit ' App " Longitude: See ° Permit ' App "
(attach separate sheet(s), if necessary, for multiple wells)

Subpart B. General Project Description:

H. General Project Description: Describe the nature, extent and schedule of the injection well project. Refer to existing and/or future pollution control facilities, expected improvement in performance of the facilities and state whether the project will result in full compliance with the requirements of Chapter 403, F.S., and all rules of the Department. Attach additional sheet(s) if necessary or cross-reference the engineering report.

This permit application is for a Class I Industrial IW System (IW System), consisting of IW-1 and IW-2, for injection of treated, non-hazardous industrial wastewater into the Lower Floridan Aquifer (LFA), specifically into a transmissive zone within the Oldsmar Formation at a depth of between approximately 2,400 and 3,300 feet below land surface (bls). the proposed IW System will be located at the Riverview Concentrate Facility (Facility), with FDEP Wastewater Permit FL0000761 and FL0177130. The source water intended for injection includes water stored in the Facility phosphogypsum stack system, the phreatic water collected by the underdrain system, and potentially other Mosaic process water (s) stored in phosphogypsum stack systems.

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: ______
DEP Application No,: ______
WACS# ______ (Filled in by DEP)

PART III. Statement by Applicant and Engineer

A. Applicant

I, the owner/authorized representative* of Mosaic Fertilizer, LLC certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I understand that this certification also applies to all subsequent reports submitted pursuant to this permit. Where construction is involved, I agree to retain the design engineer, or other professional engineer registered in Florida, to provide inspection of construction in accordance with Rule 62-528.455(1)(c), F.A.C.

Signed ______ Date 10/17/2023

Greg Howard - General Manager, Riverview
Name and Title (Please Type)

863-255-7584
Telephone Number

*Attach a Letter of Authorization.

B. Professional Engineer Registered in Florida

This is to certify that the engineering features of this injection well have been designed/examined by me and found to be in conformity with modern engineering principles applicable to the disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgement, that the well, when properly maintained and operated, will discharge the effluent in compliance with all applicable statutes of the State of Florida and the rules of the Department. It is also agreed that the undersigned will furnish the applicant a set of instructions for proper maintenance and operation of the well or ensure they have been furnished.

This item has been digitally signed and sealed by Jon M. Dinges on the date adjacent to the seal.
Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

JON MICHAEL DINGES LICENSE No. 54747 STATE OF FLORIDA PROFESSIONAL ENGINEER

(Please Affix Seal)

Signed ______

Jon M. Dinges
Name (Please Type)

Black & Veatch
Company Name (Please Type)

1715 N. Westshore Boulevard, Suite 725, Tampa, FL 33607
Mailing Address (Please Type)

Florida Registration No. 54747 Date 10/17/2023 Phone No. 386-361-5374

Email of P.E.: dingesj@bv.com

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: .
DEP Application No,: .
WACS#_____________(Filled in by DEP)

ENGINEERING AND HYDROLOGIC DATA REQUIRED FOR SUPPORT OF APPLICATION TO CONSTRUCT, OPERATE, AND ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

The following information shall be provided for each type of permit application.

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data.

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program.

15. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

N/A **B. CLASS I INJECTION WELL OPERATION PERMIT**

1. A report shall be submitted with each application for a Class I Well operating permit, which shall include, but not be limited to, the following information:

   (a) Results of the information obtained under the construction permit described in A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT, including:

      (1) All available logging and testing program data and construction data on the well or well field;

      (2) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C;

      (3) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

      (4) The actual injection procedure;

      (5) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone; and,

      (6) The status of corrective action on defective wells in the area of review.

   (b) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

   (c) Certification of completion submitted by the engineer of record;

   (d) If requested by the Department, operation manual including emergency procedures;

   (e) Proposed monitoring program and data to be submitted;

(f) Proof that the existence of the well has been recorded on the surveyor's plan at the county courthouse; and,

(g) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

N/A **C. CLASS I WELL OPERATION REPERMITTING**

1. An updated map showing the location of the injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of pubic record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the injection zone, confining zone, or monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

7. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

8. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

9. A report shall be submitted with each application for repermitting of Class I Well operation which shall include the following information:

    (a) All available logging and testing program data and construction data on the well or well field;

(b) A satisfactory demonstration of mechanical integrity for all wells pursuant to Rule 62-528.300(6), F.A.C.;

(c) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

(d) The actual injection procedure;

(e) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone;

(f) The status of corrective actin on defective wells in the area of review;

(g) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

(h) Certification of completion submitted by the engineer of record;

(i) An updated operation manual including emergency procedures;

(j) Proposed revisions to the monitoring program or data to be submitted; and,

(k) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

N/A

D. CLASS I WELL PLUGGING AND ABANDONMENT PERMIT

1. The reasons for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods, and justification for use.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

N/A **E. CLASS III WELLS CONSTRUCTION/OPERATION/PLUGGING AND ABANDONMENT PERMIT**

Construction Phase

1. A map showing the location of the proposed injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water system, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data:

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids, including any additives.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures or catastrophic collapse, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, and a drilling, testing and coring program.

15. A certificate that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

16. Expected changes in pressure, native fluid displacement, direction of movement of injection fluid.

17. A proposed monitoring plan, which includes a plan for detecting migration of fluids into underground sources of drinking water, a plan to detect water quality violation in the monitoring wells, and the proposed monitoring data to be submitted.

Operation Phase

1. The following information shall be provided to the Department prior to granting approval for the operation of the well or well field:

   (a) All available logging and testing program data and construction data on the well or well field;

   (b) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C.;

   (c) The actual operating data, including injection pressure versus pumping rate where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

   (d) The results of the formation testing program;

   (e) The actual injection procedure; and,

   (f) The status of corrective action on defective wells in the area of review.

Plugging and abandonment Phase

1. The justification for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

N/A **F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT**

1. Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.

2. Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

3. Proposed other uses of the exploratory well.

4. Drilling and testing plan for the exploratory well. The drilling plan must specify the proposed drilling program, sampling, coring, and testing procedures.

5. Abandonment Plan.

N/A **G. CLASS V WELL CONSTRUCTION PERMIT**

(This form should be used for Class V Wells instead of Form 62-528.900(3), F.A.C., when there is a need for a Technical Advisory Committee and an engineering report.)

1. Type and number of proposed Class V Wells:

________ Wells Receiving Domestic Waste

________ Desalination Process Concentrate Wells (Reverse Osmosis, etc.)

________ Aquifer Storage and Recovery Wells

________ Aquifer Remediation Wells

________ Salt-water Intrusion Barrier Wells

________ Cooling Water Return Flow Wells Open-looped System

________ Subsidence Control Wells

________ Aquifer Recharge Wells

________ Experimental Technology Wells

________ Wells used to inject spent brine after halogen recovery

________ Radioactive Waste Disposal Wells*

________ Borehole Slurry Mining Wells

________ Other non-hazardous Industrial or Commercial Disposal Wells

(explain) ____________________

________ Other (explain) ____________________

*Provided the concentrations of the waste do not exceed drinking water standards contained in Chapter 62-550, F.A.C.

2. Project Description:

   (a) Description and use of proposed injection system;

   (b) Nature and volume of injected fluid (the Department may require an analysis including bacteriological analysis) in accordance with Rule 62-528.635(2)(b), F.A.C.; and,

   (c) Proposed pretreatment.

3. Water well contractor's name, title, state license number, address, phone number and signature.

4. Well Design and Construction Details. (For multi-casing configurations or unusual construction provisions, an elevation drawing of the proposed well should be attached.)

   (a) Proposed total depth;

   (b) Proposed depth and type of casing(s);

   (c) Diameter of well;

   (d) Cement type, depth, thickness; and,

   (e) Injection pumps (if applicable): ______ gpm @ ______ psi

   Controls: ______

5. Water Supply Wells - When required by Rule 62-528.635(1), F.A.C., attach a map section showing the locations of all water supply wells within a one-half (1/2) mile radius of the proposed well. The well depths and casing depths should be included. When required by Rule 62-528.635(2), F.A.C., results of bacteriological examinations of water from all water supply wells within one-half (1/2) mile and drilled to approximate depth of proposed well should be attached.

6. Area of review (When required by Rule 62-528.300(4), F.A.C.)

   Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

N/A **H. CLASS V WELL OPERATION PERMIT**

(Final report of the construction that includes the following information may be submitted with the application to operate.)

1. Permit Number of Class V Construction Permit: ______

2. Owner's Name: ______

3. Type of Wells: ______

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4. Construction and Testing Summary:

(a) Actual Dimensions:

Diameter (inches)	Well Depth (feet)	Casing Depth (feet)

(b) Result of Initial Testing

5. Proposed Operating Data:

(a) Injection Rate (GPM);

(b) Description of injected waste; and,

(c) Injection pressure and pump controls.

6. Proposed Monitoring Plan (if any):

(a) Number of monitoring wells;

(b) Depth(s);

(c) Parameters;

(d) Frequency of sampling; and,

(e) Instrumentation (if applicable) Flow ______

Pressure ______

I. CLASS V WELLS PLUGGING AND ABANDONMENT PERMIT N/A

1. Permit number of Class V construction or operating permit.

2. Type of well.

3. Proposed plugging procedures, plans and specifications.

4. Reasons for abandonment.

N/A **J. MONITOR WELL PERMIT**

This section should be used only when application is made for a monitor well only. If a monitor well is to be constructed under a Class I, III, or V injection well permit, it is not necessary to fill in this section.

1. A site map showing the location of the proposed monitor wells for which a permit is sought. The map must be to scale and show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, water wells and other pertinent surface features including structures and roads.

2. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

3. Maps and cross sections detailing the hydrology and geologic structures of the local area.

4. Generalized maps and cross sections illustrating the regional geologic setting.

5. Proposed formation testing program to obtain an anlysis of the chemical, physical and radiological characteristics of and other information on the monitor zone(s).

6. Proposed monitoring procedure.

7. Engineering drawings of the surface and subsurface construction details of the monitoring system.

8. Proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

9. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program

10. Monitor Well Information:

☐ On-site ☐ Multizone ☐ Single-zone

☐ Regional ☐ Other (specify) ____________________

Proposed Monitoring Interval(s) ____________________

Distance and Direction From Associated Injection Well

____

CERTIFICATE OF OFFICER
OF MOSAIC FERTILIZER, LLC
AS TO AUTHORIZATION

The undersigned, Kelly J. Strong, does hereby certify that he is the duly elected Vice President – Operations, Mining North America of Mosaic Fertilizer, LLC, a Delaware limited liability company (the "Company") and further certifies as follows:

1. Greg Howard, in his capacity as General Manager – Riverview for the Company, is authorized to execute and submit all routine environmental reports, permit applications and follow-up responses, where the signature of an officer is not otherwise mandated by law, statute, or regulation.

2. The signature appearing opposite Mr. Howard's name is a true and correct specimen of his signature:

NAME:	TITLE:	SIGNATURE:
Greg Howard	General Manager – Riverview	

In witness whereof, the undersigned has executed this document effective this 16 day of October, 2023.

IRINA MARIE GALEONE
Notary Public - State of Florida
Commission # HH 340649
My Comm. Expires Dec 12, 2026

Kelly J. Strong
Vice President – Operations, Mining North America

Subscribed and sworn to before me this 16 day of October 2023.

Notary Public

2.0 Introduction

This section addresses the requirements of Part II, Subpart B, General Project Description, as well as Part A of the Engineering and Hydrologic Data Required for Support of Application to Construct, Operate, and Abandon Class I, III or V Injection Well Systems. In accordance with FDEP Underground Injection Control (UIC) guidance, the proposed Class I Industrial Injection Well (IW) will adhere to all applicable permitting, design, construction, and testing criteria.

This permit application is for a Class I Industrial IW System (IW System), consisting of IW-1 and IW-2, for injection of treated, non-hazardous industrial wastewater into the Lower Floridan Aquifer (LFA), specifically into a transmissive zone within the Oldsmar Formation at a depth of between approximately 2,400 and 3,300 feet below land surface (bls). The applicant and the owner of the well is Mosaic Fertilizer, LLC. (Mosaic), and the proposed IW System will be located at the Riverview Concentrate Facility (Facility), with FDEP Wastewater Permit FL0000761 and FL0177130. The Facility is located in west Central Florida, as shown in **Exhibit 1**. The source water intended for injection includes water stored in the Facility phosphogypsum stack system, the phreatic water collected by the underdrain system, and potentially other Mosaic process water(s) stored in phosphogypsum stack systems. The source water will undergo pre-treatment to adjust the water chemistry for compatibility with the subsurface formations.

Exhibits 2A and **2B** show the potential locations of the proposed IW System, the associated dual zone monitoring well, DZMW-1, and proposed pad monitoring wells (PMWs). The exact location will depend on infrastructure layout and other site constraints. Both IW-1 and IW-2 will be located within 150 feet of DZMW-1.

The pre-treatment edifice will be designed concurrently with the permitting and construction phase of the IW System. Pre-treatment will address injectate water chemistry to meet regulatory standards for Class I injection and chemical compatibility with the injection zone. Pre-treatment is a multi-staged chemical process including precipitation aids, pH adjustment, filtration and anti-scalants to clarify the injectate and inhibit clogging of the injection zone. The pre-treatment building will be located at the Facility.

2.1 Class I Industrial Injection Well Design Criteria

The IW System will inject non-hazardous, pre-treated industrial wastewater into the Lower Floridan Aquifer (LFA), specifically into a transmissive zone within the Oldsmar Formation at a depth of between approximately 2,400 and 3,300 feet bls.

The IW System will be constructed with a 20-inch OD seamless steel final casing and a 10.72-inch ID FRP Red Box 1250 tubing installed to the base of the 20-inch OD seamless steel final casing along with packer seals immediately above the injection zone.

In accordance with final casing fluid velocity limitations of the IW System (10 feet per second [feet/sec]), the maximum anticipated injection will be 2,775 gallons per minute (gpm), approximately 4.00 Million Gallons per Day (MGD).

2.2 Well Design, Testing and Monitoring Details

The IW System is designed to FDEP standards and the injectate will be pre-treated, non-hazardous water stored in the Facility phosphogypsum stack system, the phreatic water collected by the underdrain

system, and potentially other Mosaic process water(s) stored in phosphogypsum stack systems from the Facility.

2.2.1 Industrial Well Design

As shown in **Exhibit 3**, IW-1 and IW-2 are multi-staged cased wells with a total depth (TD) of approximately 3,300 feet bls. They will be constructed with four (4) telescoped steel casings (50-inch, 40-inch, 30-inch, and 20-inch OD) installed to isolate individual groundwater production zones as they are drilled to depth. FRP casing will be installed and cemented to surface inside the 20-inch OD seamless steel final casing along with a packer seal immediately above the injection zone. All steel casings installed during construction will have their annular spaces fully cemented to land surface. The final casing landing depth will be approximately 2,400 feet bls, utilizing 20-inch OD (0.500-inch wall thickness) seamless steel final casing. The IW System estimated total depth of 3,300 feet bls is approximately 900 feet below the landing depth of the 20-inch OD seamless steel final casing. The injection zone is in the Oldsmar Formation of the LFA.

The base of the Underground Source of Drinking Water (USDW) (an aquifer that contains a Total Dissolved Solids [TDS] concentration of less than 10,000 mg/L) was estimated at 610 feet bls and is discussed further in Items No. 2 and 4 of Section 3 of this document. The 50-inch OD pit carbon steel casing will be installed to a depth to be determined by the contractor. The anticipated casing seating depths are: 40-inch OD surface carbon steel casing installed to approximately 420 feet bls, 30-inch OD intermediate carbon steel casing installed below the base of the USDW to an approximate depth of 1,500 feet bls, the 20-inch OD seamless steel final casing will be installed to approximately 2,400 feet bls and the 10.72-inch ID FRP Red Box 1250 tubing will be installed to approximately 2,390 feet bls. All final casing landing depths and TD of the IW System will be determined during construction and the 30-inch and 20-inch OD casing setting depths will be submitted to FDEP for prior approval.

During construction, and subject to the Department's approval, Mosaic may use an American Society for Testing and Materials (ASTM) C595M-21PLC/Type 1L cement with up to 6% bentonite or higher, by weight. Type II or IL neat cement will be used to cement the 50-inch and 40-inch OD carbon steel casings from their bases to ground surface. Type II or IL neat cement will be used to cement the 30-inch, 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing from their bases in the casing-to-formation intervals and below the USDW. Type II or IL cement with up to 6% bentonite by weight may be used to cement the casing-inside-casing intervals above the USDW to ground surface for the 30-inch and 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing.

2.2.2 Dual Zone Monitoring Well

The industrial IW system will include one Dual-Zone Monitoring Well, DZMW-1, for continuous monitoring of hydraulic head within two (2) monitoring zones, the Upper Monitoring Zone (UMZ) and Lower Monitoring Zone (LMZ). The UMZ will be located just above the base of the USDW and the LMZ will be located below the base of the USDW. The LMZ will be above the principal confining strata in the lowermost permeable unit below the base of the USDW. DZMW-1 will also be used for collection of groundwater samples for laboratory analysis during IW system operation. The proposed UMZ and LMZ are anticipated to be located within the intervals from approximately 400 feet to 500 feet bls and 800 feet to 900 feet bls, respectively. The monitoring intervals will be confirmed during the construction of IW System. Following interval testing during the drilling of DZMW-1, groundwater quality will be evaluated, and the results provided to FDEP for final monitoring interval selection and approval.

DZMW-1 will have dedicated pumps and tubing installed to facilitate purging and collection of ground water samples produced from the monitoring zones to the industrial IW system. The final design of DZMW-1 will be contingent upon the results of drilling and testing.

Operational testing and monitoring data collected from DZMW-1 monitoring zones will include permit specified groundwater quality analyses and the hydraulic head (elevation in feet) in both monitoring zones. Upon FDEP's approval to commence operational testing, this data will be electronically measured and recorded for submittal with monthly operating reports (MORs).

Exhibit 3 presents the DZMW-1 subsurface construction details.

2.2.3 Drilling Fluid Containment Pad

During drilling and testing, the IW system and associated DZMW-1 will be isolated within temporary fabricated-steel (or equivalent) fluid containment pads beneath the drilling rigs and substructures. Temporary fabricated-steel (or equivalent) secondary containment pads will be used beneath the mud tanks, pumps, and fuel tanks. Submittals provided by the drilling contractor related to the design and construction of the fluid containment pads will be submitted to FDEP for approval prior to the initiation of construction activities.

2.2.4 Shallow Pad Monitoring Well Design

Twelve (12) shallow Pad Monitoring Wells (PMWs) are planned to surround IW-1, IW-2 and DZMW-1, for Surficial Aquifer System (SAS) water level and water quality monitoring as shown in **Exhibit 2A** and **2B**. The locations of these shallow PMWs will be submitted to FDEP for approval prior to their installation and initiation of construction activities. Construction details of the PMWs are detailed in **Exhibit 4**.

2.2.5 Instrumentation and Control

Temporary wellhead completion details for the IW System and associated DZMW-1 are provided in **Exhibit 5**. Monitoring of data from the IW System will be designed to meet the Class I Industrial Injection Well Construction Permit requirements to ultimately allow for operational testing of the IW System. Design drawings for surface facilities will be submitted at a later date as part of a separate permitting submittal supporting this application.

2.2.6 Testing During Construction

Well construction relies on pilot holes to confirm stratigraphic targets predicted in the IW System and DZMW-1. Lithological samples are collected at 10 foot intervals during pilot hole drilling during direct mud rotary drilling and reverse air drilling methods. Mechanical surveys will be completed at 90-foot intervals to verify drilling trajectory. Once construction switches from direct mud rotary drilling to reverse air drilling method at approximately 420 feet bls, reverse air water quality samples will be collected at 45-foot intervals, in addition lithological samples are collected at 10 foot intervals. Geophysical logging will be conducted at the completion of every drilling stage. Hydrogeological testing and associated water analysis will be completed below the base of the USDW. Core samples and packer tests will be evaluated to characterize the subsurface hydrogeology. This information will confirm final IW System designs with respect to casing set depths, total borehole depth, and the associated Well DZMW-1 monitoring zones. The current testing and coring schedule for the IW System and associated DZMW-1 are shown as a schematic in **Exhibit 6A, Exhibit 6B and Exhibit 6C**.

2.3 Final Injection Testing and Operational Testing

Following the construction of IW System and associated DZMW-1, written authorization for final injection testing will be requested from the FDEP. This authorized testing phase will commence following well completion and mechanical integrity testing (MIT) and will include short-term injection using freshwater and/or pre-treated non-hazardous process wastewater .Following successful completion of the short-term injection test and wellhead facilities' construction, written authorization for full-scale operational testing will be requested from the FDEP. The proposed monitoring program for operational testing is described in **Exhibit 7** and is in compliance with the FDEP-required parameters and frequency specified in the construction permit. Operational data including wellhead pressure, flow rates and injection volumes for the IW System, will have continuous recording in place with limit specifications. The injectate will be sampled and analyzed for the parameters required in the Class I Industrial Injection Well Construction Permit, once issued, following the FDEP required frequency. As required for the Class I Industrial Injection Well Construction Permit operational testing phase, an initial waste stream analysis will be collected from the Facility pre-treatment system for the following water quality parameters prior to operation:

- Primary Drinking Water Standards; excluding asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine;
- Secondary Drinking Water Standards; and Wastewater Quality Indicators

3.0 Class I Industrial Injection Well Construction Permit Supporting Data

(Responses to Part A of Form 62-528.900(1))

The following addresses the information specifically required in FDEP UIC permit application (FDEP Form 62-528.900(1)), pages 4 and 5 of Section A "CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT". The permit application required information is shown in bold type followed by the supporting technical information.

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. **A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.**

The proposed Facility IW System will be located in Hillsborough County, Florida, as shown in **Exhibits 1, 2A** and **2B.** The preliminary coordinates (World Geodetic System 1984 [WGS84]) are shown below in **Table 3-1** and **Table 3-2** and include the coordinates for the IW System, and associated proposed Well DZMW-1. The calculations presented in **Exhibit 8A** indicate that the injected fluids could migrate approximately 3,965 feet (0.75 miles) over a 10-year period (two permit durations), assuming a maximum continuous injection rate of 4.0 MGD occurs for this IW System. **Exhibit 8B** provides a plot of the theoretical effective radial distance of influence over time. The injectate front calculation assumes a conservative injection zone vertical thickness of 200 feet and an effective porosity of 0.20 (dimensionless) based on current FDEP guidance.

Table 3-1 Proposed Injection and Dual Zone Monitoring Well Primary Location Coordinates

Well ID	Latitude	Longitude
IW-1 (Proposed)	27° 52' 13.051" N	82° 23' 7.475" W
IW-2 (Proposed)	27° 52' 10.074" N	82° 23' 7.4832" W
DZMW-1 (Proposed)	27° 52' 11.571" N	82° 23' 7.468" W

Table 3-2 Proposed Injection and Dual Zone Monitoring Well Secondary Location Coordinates

Well ID	Latitude	Longitude
IW-1 (Proposed)	27° 51' 52.2" N	82° 23' 24.70" W
IW-2 (Proposed)	27° 51' 49.20" N	82° 23' 24.66" W
DZMW-1 (Proposed)	27° 51' 50.71" N	82° 23' 24.69" W

Using a conservative 1-mile radius, the Facility property along with the 1-mile Area of Review (AOR), major roads and surface water bodies are shown in aerial maps in **Exhibits 9A** through **9I**. The construction site at the Facility, shown in **Exhibit 2A** and **Exhibit 2B**, is predominantly flat with elevations ranging between 18.2 and 20.2 feet above the North American Vertical Datum of 1988 (NAVD 88). The Facility is located in an urban area composed by residential, commercial and recreational land uses, and is adjacent to Hillsborough Bay.

A well inventory within the 1-mile radius was completed in April 2023 as part of this Class I Well Construction permit application. Wells within the public domain databases from the United States Geological Survey (USGS), Florida Geological Survey (FGS) Bureau of Mining and Minerals, FDEP, and Southwest Florida Water Management District (SWFWMD) were reviewed. A total of 1,213 wells were identified within the AOR. Since the AOR analysis is done reviewing the databases described above, independently of each other, there may be wells that appear in one or more databases and duplicates are therefore possible. **Exhibit 9J** provides an updated tabulation of wells found within the AOR; the wells are indexed and presented on the aerial maps shown in **Exhibit 9A** through **9I**. It is to be noted that there is overlapping in some of the aerial maps and therefore **Exhibit 9J** provides the tabulation of all wells. Exhibits are outlined as follows:

- **Exhibit 9A**: USGS Database Wells within the 1-mile AOR;
- **Exhibit 9B**: SWFWMD Database Wells within the 1-mile AOR;
- **Exhibit 9C**: FGS Database Wells within the 1-mile AOR;
- **Exhibit 9D**: FDEP Database UIC Monitoring Wells within the 1-mile AOR;
- **Exhibit 9E**: FDEP Database UIC Class V Non-ASR Wells within 1-mile AOR;
- **Exhibit 9F**: FDEP Database UIC Class V ASR Wells within 1-mile AOR;
- **Exhibit 9G**: FDEP Database UIC Class I Wells within the 1-mile AOR;
- **Exhibit 9H**: Oil and Gas Database Wells within the 1-mile AOR;
- **Exhibit 9I**: Mosaic Wells within the 1-mile AOR;
- **Exhibit 9J:** Tabulation of Wells Found within 1-mile AOR.

Within the AOR, there are no wells known to be improperly abandoned, and none of the wells identified penetrate the injection zone or confining zones. Several wells penetrate the monitoring zones as shown below. The deepest well in the AOR is a Class V injection well that was completed into the Avon Park Formation with a total depth of 1,100 feet bls. **Table 3-2** and **Table 3-3** summarize the wells separated by agency database, well type, and maximum depth.

Table 3-3 Summary of wells per database inside AOR

Agency	Monitor	Class V Non-ASR	Class V ASR	Domestic/Public Supply	Unknown/Other	Total
USGS	44	0	0	0	0	44
SWFWMD	547	0	0	98	506	1151
FGS	1	0	0	1	12	14
FDEP	2	1	1	0	0	4

Table 3-3 below summarizes the maximum depth within the AOR databases. Plugged and abandoned wells and proposed wells are included.

Table 3-4 AOR, Summary of Wells Maximum Depth (feet bls)

Agency	Monitor	Class V Non-ASR	Class V ASR	Domestic/Public Supply	Unknown/Other	Maximum Depth
USGS	1,000					1,000
SWFWMD	745			360	1,068	1,068
FGS	470			65	1,075	1,075
FDEP	860	1,100	500			1,100

USGS Well Inventory

In the USGS database, shown in **Exhibit 9A**, 44 wells are documented within the AOR for this well survey. The wells vary in depth from 12 feet to 1,000 feet bls (and one of unknown depth), with the deepest well located within the property boundary of the Facility. Based on the location and depths of these wells, they are not expected to be affected by the operation of the proposed IW system.

SWFWMD Well Inventory

A total of 1,151 wells were identified within the AOR in the SWFWMD wells inventory, shown in **Exhibit 9B**. The wells identified in the AOR were classified as:

- 92 Domestic
- 3 Dewatering
- 547 Monitoring
- 1 Heating, Ventilation, and Air Conditioning (HVAC)
- 8 Industrial
- 168 Irrigation

- 4 Livestock
- 285 Plugged
- 6 Public Supply
- 1 Repair Irrigation
- 4 Repair or Deepen (use not specified)
- 32 Test

The wells identified in the SWFWMD inventory range from 6 feet to 1,068 feet bls, with the deepest well permitted to Cargill Fertilizer now Mosaic, was plugged and abandoned. Based on the location and depths of these wells, they are not expected to be affected by the operation of the proposed industrial IW system.

FGS Well Inventory

In the FGS database, shown in **Exhibit 9C**, 14 wells are documented within the AOR for this well survey. The wells identified in the AOR were classified as:

- 8 Industrial wells
- 2 Industrial wells Heat pump/Air Conditioning (HAC)
- 1 Commercial well
- 1 Public supply well
- 1 Monitor well
- 1 Unknown use well (plugged and abandoned)

The wells identified in the FGS inventory range from 65 feet to 1,075 feet in depth. The deepest documented wells are permitted to U.S. Phosphoric Products, now Mosaic. Based on the location and depths of these wells, they are not expected to be affected by the operation of the proposed IW System.

FDEP Well Inventory

A total of 4 wells were identified within the 1-mile AOR in the FDEP well inventory. The wells identified in the AOR is classified as:

- 2 Monitoring wells (**Exhibit 9D**)
- 1 Class V non-aquifer storage and recovery (ASR) well (**Exhibit 9E**)
- 1 Class V ASR well (**Exhibit 9F**) (not constructed)
- 0 Class I Industrial Injection well (**Exhibit 9G**)

The two (2) monitoring wells in the database are completed to a depth of 250 feet and 860 feet bls, respectively, and are part of an aquifer recharge project owned by Hillsborough County (South Hillsborough Aquifer Recharge [SHARE]). The Class V non-ASR well is identified as a recharge well and is constructed with a cased depth of 710 ft bls and a total depth of 1,100 feet bls, also owned by Hillsborough County's SHARE project. The Class V ASR well identified in **Exhibit 9F** was proposed to be constructed with a cased depth of 400 feet bls and a total depth of 500 feet but has not been constructed. Based on the information provided in the FDEP inventory, no local existing use is expected to be affected by the proposed industrial IW system.

Mosaic Inventory

A total of 285 Mosaic wells are identified within the AOR. These wells are shown within the well inventories of the USGS (2 wells), SWFWMD (272 wells), FGS (10 wells), and FDEP (1 well) and are shown in **Exhibit 9I**. The owner of these wells, Mosaic, is identified in the well inventories under various predecessor or alternate names such as Cargill Fertilizer, Inc., Gardinier, Inc., Mosaic Fertilizer, or U.S. Phosphoric Products, Inc.

Table 3-4 below summarizes the Mosaic wells within the AOR databases. Plugged and abandoned wells and proposed wells are included.

Table 3-5 Summary of Mosaic wells per database inside AOR

Agency	Monitor	Class V Non-ASR	Class V ASR	Domestic/Public Supply	Industrial/Other/Unknown	Total
USGS	2	0	0	0	0	2
SWFWMD	162	3	0	1	106	272
FGS	0	0	0	0	10	10
FDEP	0	0	1	0	0	1

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

Based on best available information obtained from data of existing wells located within the AOR, the base of the USDW is estimated to be encountered at 610 feet bls at the Facility. **Exhibits 9A** through **9I** show wells within the AOR previously discussed in Item No. 1. The updated well inventory conducted in support of this permit application indicates the following:

- No wells located inside the Facility penetrate the proposed injection zone from 2,400 feet to 3,300 feet bls.
- No wells were identified that have penetrated the confinement zones above the injection zone.
- Two wells penetrate the UMZ or LMZ outside of Mosaic's holdings as shown in Table 9J and listed below:
  - One (1) inactive USGS groundwater monitoring well completed to 1,000 feet bls.
  - One (1) Active Hillsborough County Recharge Well completed to 1,100 feet bls.

Interference is not expected between the identified wells that penetrate the proposed IW system depths due to the construction details, confinement and the transmissivity of the Oldsmar Formation.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection

formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

Exhibit 10 describes the Floridan Aquifer System (FAS) terminology (Williams and Kuniansky, 2015) and **Exhibit 11** describes the hydrostratigraphy of the FAS based on the hydrogeologic framework report, Synthesis of the Hydrogeologic Framework of the FAS and Delineation of a Major Avon Park Permeable Zone (APPZ) in Central and Southern Florida (Reese, R. S. and Richardson E., 2007).

Exhibits 12A, 12B and **12C** present a location map and hydrogeologic cross-sections for wells within Sumter, Hernando, Pasco, Hillsborough, Manatee, Pinellas, Polk and Sarasota Counties. The cross-sections were developed based on the FDEP UIC Class I Injection Wells database (FDEP, 1990), for which the delineation of hydrostratigraphic boundaries were established primarily from the construction and testing reports of nearby wells as well as interpretation of geophysical logs and lithologic data. Hydrostratigraphic data for the existing wells located near the Facility was also included on the cross-sections.

Exhibit 13A shows a potentiometric map of the Upper Floridan Aquifer (UFA) which shows groundwater flow is toward the coast (West). **Exhibit 13B** shows the thickness of the Upper Confining Unit of the FAS in the area of the Facility. **Exhibit 13C** and **Exhibit 13D** show the elevation of the upper and lower contact of the FAS (100 feet National Geodetic Vertical Datum 29 [NGVD 29] and -3200 feet NGVD 29, respectively) near the Facility. Since no operational UIC Class I wells were identified in the AOR, the presence of effluent/concentrate in the proposed injection zone or confining units is not expected during drilling and testing of the proposed IW System.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

Local hydrogeologic maps and cross-sections presented in **Exhibits 12A**, **12B**, and **12C** show the hydrogeology near the proposed Facility IW System. Review of published literature did not reveal any confirmed geologic, tectonic, or physiographic structures, such as faults, folds, or penetrating sinkholes, within the local area. Regional information on the geologic setting is presented below in Item No. 5.

Mosaic plans to construct the IW System within the boundaries of the Facility's property. Based on available data presented in the cross-sections (**Exhibits 12A**, **12B**, and **12C),** the base of the USDW is estimated to be encountered at an approximate depth of 610 feet bls, indicated primarily on **Exhibit 12B**, since there was more data available on nearby wells to estimate the base of the USDW.

At the Facility, the proposed injection zone will be within the LFA, specifically, the Oldsmar Formation. The top of the Oldsmar formation is found at approximately 2,350 feet bls. The bottom of the LFA within the Oldsmar Formation is expected to extend to approximately 3,300 feet bls. An interval of approximately 1,740 feet in thickness separates the base of the USDW and the top of the Oldsmar Formation at the Facility (**Exhibit 12B**).

A Geologic Structure Map of Florida is shown in **Exhibit 14** with a summary of the hydrostratigraphy. **Exhibit 15** depicts the Geologic Units of Florida from Holocene to Eocene Epochs, or land surface to approximately 3,200 feet bls. **Exhibit 15** shows the larger scale geological Map of Florida's Southern Peninsula depicting the Facility situated in the Peace River Formation of the Hawthorn Group. This local section was compiled from cross-section interpolations shown on previously mentioned **Exhibit 12B** and **12C**, along with elevations and dimensions from maps of the FAS appearing in previously mentioned **Exhibits 13A** through **13D**. The shallow stratigraphy was inferred from both the regional cross-sections and a cross-section local to the Facility (**Exhibit 12A**).

The locations of hydrogeologic cross-sections A-A' and B-B' are shown on section line maps provided in **Exhibit 12A**. The cross-sections were constructed for this application using hydrogeologic interpretations from engineering reports and published literature for the following localities:

- ROMP 102-5
- Larkin Co #8-4 P-743
- ROMP 86A
- SHARP SRWD-2 class v recharge well
- SHARP RW-1
- W-16618
- Manatee County Utilities' IW-1
- COS RO WTP DIW-1
- P-75 Coastal Wright 1
- ROMP 49
- P-29 Humble Jameson 1
- TECO IW1&IW2
- ROMP 45-5
- P-403 Shepard Dairy Inc-1

At the Facility, the uppermost aquifer system is the SAS. This aquifer system comprises undifferentiated sediments mainly composed of unconsolidated quartz sand with variable amounts of clay (ASRus, 2023). The SAS is underlain by the Peace River and Arcadia Formation sediments of the Miocene Epoch, which comprise the Hawthorn Group. The Peace River Formation is an orange limestone with phosphate sands and gravels, and quartz sand. The Tampa Member of the Arcadia Formation grades from a light orange clay to a fine crystalline limestone ranging from light orange-light brown at the top of the formation, to a cryptocrystalline/microcrystalline white limestone. Beneath the Facility, these sediments are anticipated to exhibit a thickness of approximately 135 feet.

The top of the FAS is encountered near the base, or immediately below the Hawthorn Group, estimated at a depth that is approximately 160 feet bls. Beneath the Facility, the FAS consists of the Oligocene Epoch Suwannee Limestone, Crystal River Formation, and Ocala Limestone; and the Eocene Epoch Avon Park and Oldsmar Formations. The FAS contains several highly permeable zones interbedded with less permeable units. The zones of highest permeability typically occur at or near unconformities and are usually oriented sub-parallel to bedding (Meyer, 1989). In west-central Florida, the FAS consists of the following aquifer units presented from shallowest to deepest:

- UFA
- APPZ
- LFA
- Oldsmar Permeable Zone (OLDSPZ)

The UFA and the APPZ are grouped into the UFA system, while the OLDSPZ is located in the LFA system (Reese and Richardson, 2007).

Researchers (Miller 1986; Reese, 1994) have described multiple discrete confining units separating the individual aquifers. A single unit, the middle confining unit 2 (MCU II) separates the UFA and LFA systems. Beneath the Facility, the MCU II displays an anticipated thickness of approximately 550 feet.

Stratigraphically, the UFA falls in the Tampa member of the lower Arcadia formation and the Suwannee Limestone, while the APPZ occurs in the Avon Park Formation. The LFA is present from the lower part of the Avon Park Formation to the Oldsmar Formation. The high transmissivity zone encountered within the Oldsmar Formation is commonly known in west central Florida as the OLDSPZ.

According to lithology logs from wells drilled by the Florida Geological Survey (FGS) within the Facility (FDEP, 2018), the Suwannee Limestone is normally a white, indurated, porous calcarenite that contains numerous fossil benthic foraminifera, bryozoa and worm traces. The Suwannee Limestone is underlain by the Eocene-age Crystal River Formation, which is logged as a grayish-brown to light orange, moderate to well-indurated, cryptocrystalline to microcrystalline limestone with trace sand and sparry calcite. The Crystal River Formation is underlain by the Eocene Epoch Ocala Formation, which is logged as a light orange to grayish brown, moderately indurated fossiliferous limestone. Underneath the Ocala Formation, the Eocene-age Avon Park Formation is composed of variably textured grayish brown to pale orange fossiliferous limestone, characterized by interbedded low porosity recrystallized limestone in the lower section. In addition to the APPZ, the relatively low permeability Avon Park Formation may comprise the Middle Confining and Composite Units (Williams and Kuniansky, 2015), also referred to simply as the MCU II, as recognized on a regional scale (Miller, 1986).

Underlying the Eocene Epoch Avon Park Formation, the top of the Eocene Epoch Oldsmar Formation is anticipated to be encountered at approximately 2,350 feet bls at the Facility. The Oldsmar Formation is expected to extend to approximately 3,300 feet bls at the Facility.

5. Generalized maps and cross sections illustrating the regional geologic setting.

The proposed Facility IW System is located within the Atlantic Coastal Plain physiographic region. The region's geologic and tectonic setting is the product of a complex history of continental collisions and rifting followed by deposition of sediments on the Florida platform. Basement rocks consist of Paleozoic and Mesozoic aged igneous, metamorphic, and sedimentary rocks. The overlying Mesozoic Era carbonate and evaporite sedimentary rocks may be 15,000 feet thick (Miller, 1986). Overlying the Mesozoic Era rocks is approximately 6,000 feet of Cenozoic Era carbonate and siliciclastic sedimentary rocks (Applin and Applin, 1944, Arthur, J.D., 1988; Dallmeyer, R.D., 1989; Milton, C., 1972). The geologic structures as shown in **Exhibit 14** that have affected shallow Tertiary and Quaternary Period sediments of the Florida Platform have been defined by numerous authors (Puri and Vernon, 1974; Miller, 1986; Scott, 1988; Scott, 1992). The majority of the structures recognized as influencing the deposition, erosion and alteration of the Cenozoic Era sediments in Florida do not appear to have had a significant effect on the surface expression of the lithostratigraphic units (Scott, 1988). A geologic map of the southern peninsula is presented in **Exhibits 15**.

Previously mentioned, local hydrogeologic cross-sections for west-central Florida are shown in **Exhibits 12B** and **12C**. Regional hydrogeologic cross-sections have been included in **Exhibits 16A** through **Exhibit 16C** as presented in the report, Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina (Williams and Kuniansky, 2016). The location

of the Facility is shown for reference on the cross-sections which show the general structure of the geologic units extending from land surface through the lower Eocene formations. Hydrostratigraphic boundaries for the following units are depicted:

- SAS
- Intermediate Confining Unit (ICU)
- UFA
- MCU II
- LFA
- OLDSPZ

The Eocene-Oligocene-Miocene-Pleistocene Epochs carbonate sequence was deposited on a platform east of the South Florida Basin; a shallow, sloping depression with an axis oriented East-Northeast. Regional cross-sections oriented east to west (**Exhibit 16C**), crossing the peninsula several miles south of the Facility, and a regional cross section oriented north to south (**Exhibit 16B**), crossing the peninsula several miles east of the Facility, depicting a section that slopes gently south toward the Florida Keys.

6. Proposed operating data

a) Average and maximum daily rate and volume of the fluid to be injected;

The proposed operational protocol is dependent upon the final pipeline and valving design, which will be completed as part of the surface facility and injection pumping system design. These are currently under development and will be provided with the request for authorization to begin operational testing.

Operation of IW System will begin once the well and respective above surface facilities are completed and authorized by FDEP to begin operational testing. The maximum daily injection rate for the IW System will be 2,775 gpm (4.0 MGD).

b) Average and maximum injection pressure;

Currently, the actual injection pressure for the proposed industrial IW System is not known, therefore, the pressure at the wellhead must be estimated based on data from injection wells in the vicinity.

A Class I Deep Well Injection System, including Well IW-1 and associated dual-zone monitoring well, was recently constructed at a facility in Manatee County, FL, for Manatee County Utilities. The site is located approximately 19 miles southwest of the Facility and serves as a key well for site-specific hydrogeologic characterization for the Facility.

The results of a 50-minute injection test and a 12-hour short-term injection test from Manatee County Utilities Injection Well IW-1 were obtained from the Construction and Testing Report (ASRus, 2023) and are presented below in **Table 3-5**.

Table 3-6 Manatee County Utilities Injection Well IW-1 50-minute Injection Tests Results (ASRus, 2023)

Date	Duration	Water Source	Static Pressure (psi)	Flow Rate (gpm)	Observed Pressure During Pumping (psi)	Specific Injectivity (gpm/Δpsi)
11/18/2022	50 minutes	Potable Water	19	1,460	80	24
2/8/2023	12.2 hours	Potable Water	18.5	760	56.5	20

According to the Manatee County Utilities Injection Well IW-1 Construction and Testing Report (ASRus, 2023), it is anticipated that IW-1 will be capable of accepting the injection rate of 1 MGD at up to 150 psi, assuming this well capacity can be maintained. Transmissivity of the injection zone was estimated at 25,100 gpd/ft based on the recovery data from the injection well.

There is no operational data available from FDEP for Manatee County Utilities well, as it was recently completed.

c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids.

The source water for injection is the process water from the Facilty phosphogypsum stack system, the phreatic water collected by the associated underdrain system, and other Mosaic Concentrate facility waters stored in phosphogypsum stack systems. The source water will undergo pre-treatment to adjust the water chemistry for compatibility with the subsurface formations. The IW System will be used to assist the Facility with management of process water inventory.

The source waters will be pre-treated to meet non-hazardous waste stream criteria and are therefore not prohibited for Class I injection, provided all other requirements for a Class I industrial injection well are met per F.A.C. Chapter 62-528.

As required for the Class I Injection Well Construction and Testing Permit, a waste stream chemical analysis of treated waters proposed for injection will be provided to the Department at a later date.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

A chronological description of the drilling and testing program for the IW System, and DZMW-1 are presented below in Item No. 14 of this permit application. A tabulated summary of the geophysical logging schedule and other hydrogeological data collection procedures, such as mechanical deviation surveys and lithologic sample collection, to be conducted while drilling the IW System, and DZMW-1 are provided in **Exhibits 17A, 17B**, and **17C**, respectively.

8. Proposed stimulation program.

Depending on the injection capacity of the targeted injection zone, acidization may be performed following construction of the IW System. Prior to acidization, a plan to conduct the work will be submitted to FDEP after the target zone is evaluated.

During the life expectancy of the IW System, redevelopment techniques may be necessary to remove scale from the well casing or remove accumulations from the open hole. This will be accomplished, if necessary, by a qualified contractor. The materials proposed for use in this IW system will not be adversely affected by limited use of the small quantities of chemicals or physical tools commonly used during redevelopment activities.

9. Proposed injection procedure.

The injection procedure is dependent on the injectate pipeline and valving design which is under development, and will be provided in the operation and maintenance manual and with the request for authorization to begin operational testing. As a result, the description below is generalized.

Water will be pre-treated prior to injection for compatibility with the injection zone. Prior to operational testing, drawings of the injection well facilities will be provided, and a detailed injection procedure will also be submitted to the Department for review.

10. Engineering drawings of the surface and subsurface construction details of the system.

Exhibit 3 presents the subsurface construction details of the IW System while **Exhibit 5** presents the wellhead construction details for the IW System and DZMW-1. Surface facilities are required to receive and deliver the non-hazardous waste streams to the proposed IW System. These surface facilities will include a pump station to receive and pump the waste streams, including structures, pumps, electrical power supply, instrumentation and controls, and associated appurtenances; yard piping for delivering non-hazardous waste streams to the injection well pump station and IW System; above grade piping and controls at the IW System; and above grade piping, horizontal centrifugal sample pumps, and instrumentation and controls at the DZMW-1.

The final PE signed and sealed engineering drawings for wells and the surface facilities will be provided at a later date.

11. Contingency plans to cope with all shut-ins or well failures, to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

In the event of a well shut-in, the Facility will maintain permitted options of managing wastewater using a Reverse Osmosis system, or transferring to Mosaic's Green Bay Facility until UIC can be resumed.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

Exhibit 7 outlines the referenced Rule; a description of each Class I monitoring requirement is described with a discussion of how Mosaic will conduct monitoring during injection operations. **Table 3-6** provides a summary of the proposed monitoring program for the IW System, and Well DZMW-1. The following is a brief description of the proposed plan:

- In accordance with 62-528.425(l)(a), F.A.C., the injectate will be sampled monthly to yield representative characteristics of the injected fluid.
- In accordance with 62-528.425(l)(b), F.A.C., the IW System will use continuous indicating, recording, and totalizing devices to monitor flow rate, injection volume, and wellhead pressure. DZMW-1 will be equipped with pressure transmitters that measure and display the well pressure of each zone. All data will be reported monthly to FDEP once the system is ready for startup and approved for operational testing.
- In accordance with 62-528.425(1)(c), F.A.C., a 12-hour short-term injection test will be conducted upon completion of the IW System. The short-term injection test plan will be submitted to FDEP for approval.
- In accordance with 62-528.425(l)(d), F.A.C., internal and external MIT will be performed every five years and will include a pressure test at no more than 1.5 times the permitted wellhead pressure.
- In accordance with 62-528.425(l)(e), F.A.C., monitoring parameters and frequencies for the IW System, and Well DZMW-1 will follow the proposed monitoring schedule provided in **Table 3-6** in this Class I Injection Well Permit Application.
- In accordance with 62-528.425(l)(f), F.A.C., background groundwater samples will be collected from the injection zone, and each zone of DZMW-1. Samples will be analyzed for Industrial Wastewater Indicator Parameters and the Primary and Secondary Drinking Water Standards (62-550, F.A.C.), except asbestos, dioxin, butachlor, acrylamide and epichlorohydrin. All analytical methods and test procedures shall be in accordance with EPA's latest revision of Methods for Chemical Analysis of Water and Wastes (EPA-600/4-79-020). The UMZ and LMZ will be sampled upon the completion, development, and purging of each zone. A groundwater sample from the injection zone will be collected following the installation of the 10.72-inch ID Red Box 1250 FRP tubing and injection zone development at IW-1 and IW-2. After removal of a minimum of 1 well volume from the well and after field parameters have stabilized according to FDEP SOPs, the contractor's approved subcontracted National Environmental Laboratory Accreditation Program (NELAP) certified laboratory shall collect one (1) final unfiltered water sample and one (1) duplicate water sample. All samples shall be properly collected, preserved, stored on ice, and analyzed within the required hold time limits, following the latest version of the FDEP-Standard Operating Procedure (SOP) FDEP-SOP-001/01, FDEP Quality Assurance Rule, 62-160, F.A.C. FDEP.
- In accordance with 62-528.425(l)(g), F.A.C., Well DZMW-1 is designed to monitor the permeable unit just above the base of the USDW and the permeable unit located just above the principal confining strata and below the base of the USDW, respectively.

Table 3-7 Proposed Monitoring Program

Parameter	Unit	Recording Frequency	Frequency of Analyses		
			Proposed IW-1 & IW-2	DZMW-1 Upper	DZMW-1 Lower
Injection Pressure, max.	psi	continuous	D/M[1]	-	-
Injection Pressure, min.	psi	continuous	D/M[1]	-	-
Injection Pressure, avg.	psi	continuous	D/M[1]	-	-
Flow Rate, max.	gpm	continuous	D/M[1]	-	-
Flow Rate, min.	gpm	continuous	D/M[1]	-	-
Flow Rate, avg.	gpm	continuous	D/M[1]	-	-
Total Volume Injected	MG	daily/monthly	D/M	-	-
Water Level or Pressure, max.	feet (NAVD) or psi	continuous	-	D/M[1]	D/M[1]
Water Level or Pressure, min.	feet (NAVD) or psi	continuous	-	D/M[1]	D/M[1]
Water Level or Pressure, avg.	feet (NAVD) or psi	continuous	-	D/M[1]	D/M[1]
pH[2]	std. units	grab/purge	M	M	M
Specific Conductance[2]	µmhos/cm	grab/purge	M	M	M
Temperature[2]	degrees Celsius	grab/purge	M	M	M
Dissolved Oxygen[2]	mg/L	grab/purge	M	M	M
Turbidity[2]	NTU	grab/purge	M	M	M
Chloride	mg/L	grab/purge	M	M	M
Sulfate	mg/L	grab/purge	M	M	M
Total Dissolved Solids	mg/L	grab/purge	M	M	M
Nitrate + Nitrite as N	mg/L	grab/purge	M	M	M
Ammonia as N	mg/L	grab/purge	M	M	M
Total Kjeldahl Nitrogen	mg/L	grab/purge	M	M	M
Total Phosphorus as P	mg/L	grab/purge	M	M	M
Fluoride	mg/L	grab/purge	M	M	M
Bicarbonate	mg/L	grab/purge	M	M	M

Calcium	mg/L	grab/purge	M	M	M
Total Iron	mg/L	grab/purge	M	M	M
Magnesium	mg/L	grab/purge	M	M	M
Potassium	mg/L	grab/purge	M	M	M
Sodium	mg/L	grab/purge	M	M	M
Total Organic Carbon (TOC)	mg/L	grab/purge	M	M	M
Gross Alpha	pCi/L	grab/purge	M		M
Uranium	µg/L	grab/purge	M		M
Radium[226]	pCi/L	grab/purge	M		M
Radium[228]	pCi/L	grab/purge	M		M
Primary & Secondary Drinking Water Standards, Source Waters		3	A		

D – Daily; M – Monthly; Q – Quarterly; A - Annually

[1]Operational data reporting for flows, pressures and water levels: daily maximum, minimum and average from continuous reporting; monthly maximum, minimum and average (calculated from daily averages).

[2]Field samples.

[3]Composite and grab samples, as appropriate.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

The well inventory completed in April 2023 in support of this permit application indicates that there are no abandoned wells, known or suspected, which exist within the AOR and penetrate the proposed injection zone, therefore, this requirement is not applicable. Please refer to **Exhibits 9A** through **9I** for all wells located within the AOR.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing, and coring program.

The following section provides a chronological description of the construction including cementing and casing program, logging procedures, deviation surveys, drilling fluid containment, well drilling, and testing activities associated with the IW System and DZMW-1. **Exhibits 17A** and **17B** provide a summary of testing to be conducted while drilling the IW System and **Exhibit 17C** provides a summary of testing to be conducted while drilling DZMW-1.

A sequential description of the drilling and testing program for the IW System, DZMW-1 and associated PMWs is shown below and provides the requirements for accomplishing the drilling and testing of the well and will include information on cementing and casing programs, geophysical logging schedule, lithologic sampling, coring, packer testing, injection testing, and other hydrogeologic data collection procedures. Pilot holes drilled throughout the sequence of construction shown below will be used to verify and validate the information in the application which were obtained from maps and cross sections which

detailed the hydrology and geologic structures of the local area. Information from the pilot holes will be used to adjust casing seat depths and design the well accordingly.

The drilling contractor will construct a steel (or equal as approved by the FDEP) fluid containment pad beneath the drill rig and rig substructure with secondary containment beneath mud tanks, mud pumps and fuel tanks, prior to commencing drilling at each well location to retain drilling fluids and to prevent water quality impacts to the SAS. Additionally, the drilling contractor will coordinate the collection of water quality samples and have a NELAP certified laboratory analyze (in accordance with FDEP Standard Operating Procedures [SOPs]) the PMWs throughout construction and testing to confirm no water quality impacts to the SAS.

During well construction, it may be necessary to use an American Society for Testing and Materials (ASTM) C595M-21PLC/Type 1L cement with up to 6% bentonite or higher, by weight. This situation would be contingent upon FDEP approval.

The proposed work sequence for the mobilization and site preparation is as follows:

1. Install temporary water, sewer, electrical, wireless internet, and cell phone services.

2. Conduct a pre-construction video survey of the site to document existing site conditions.

3. Perform site preparation: clearing, grubbing, stripping and debris removal. Remove and dispose of non-hazardous debris and build up soil sub-base for drilling pad.

4. Excavate fill materials and install a 50-inch OD (wall thickness to be determined by CONTRACTOR) carbon steel pit casing to the depth required for the drilling system. The pit casing shall be installed, as needed, by the drilling contractor, to stabilize the site for drilling operations at the location of the IW. The drilling contractor will determine the appropriate depth of pit casing. The final floor elevation within the pit casing will accommodate the installation of a rotating head or other sealing mechanisms to control fluids during drilling. Excavated materials shall be stockpiled onsite at the location designated by the OWNER.

5. Construct a temporary fabricated steel (or equal) fluid containment pad. The drilling contractor shall provide containment pad details for information, which will be submitted for FDEP approval.

6. Install, develop, and sample four 4-inch diameter polyvinyl chloride (PVC) shallow PMWs at approved locations, as required by the FDEP. PMW locations are shown in **Exhibit 2A** and **2B** and PMW construction details are show in **Exhibit 4**. Background samples of water quality will be collected for analysis by a NELAP certified laboratory.

7. Mobilize drilling and other required materials and equipment required for construction.

The sequential description of drilling and testing for IW-1 is as follows:

1. Drill a pilot hole with a 12.25-inch diameter bit to approximately 500 feet bls using the direct mud-rotary method. Record mechanical deviation surveys and collect rock formation samples in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1.**

2. Conduct geophysical logging [Caliper (CAL), natural gamma-ray (NGR), spontaneous potential (SP), dual-induction (DIL), borehole compensated sonic w/ variable density log (BHCS/VDL), Acoustic Borehole Imager (ABI)] in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

3. Ream the pilot hole to a nominal 50-inch diameter borehole to approximately to 425 feet bls using the direct mud-rotary method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

4. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

5. Install the 40-inch OD carbon steel surface casing (0.500-inch wall) to approximately 420 feet bls in accordance with **Exhibit 3 - Mosaic Riverview Deep Injection Well No. 1 and Dual-Zone Monitor Well Construction Details**, and cement to surface.

6. Conduct geophysical logging [Temperature (TEMP) and NGR after each cement stage] in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

7. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

8. Drill out cement plug and drill a pilot hole centered at the bottom of the 40-inch OD carbon steel surface casing with a 12.25-inch diameter bit to approximately 1,600 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

9. Collect up to four (4) rock cores during pilot hole drilling below the 40-inch OD carbon steel surface casing at depths selected by the ENGINEER in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

10. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, video survey (TV) or Optical Borehole Imager (OBI) or ABI, TEMP, fluid resistivity (FR) and flowmeter (FM); Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

11. Conduct up to four (4) packer tests at depths selected by the ENGINEER in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

12. Back-plug the pilot hole with cement to the base of the 40-inch OD carbon steel surface casing.

13. Ream the pilot hole to a nominal 40-inch diameter borehole to approximately 1,505 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

14. Conduct geophysical logging (CAL and NGR) in the reamed hole in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

15. Install the 30-inch OD carbon steel intermediate casing to approximately 1,500 feet bls in accordance with **Exhibit 3 – Mosaic Riverview Deep Injection Well No. 1 and Dual-Zone Monitor Well Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

16. Drill out cement plug and drill a pilot hole centered at the bottom of the 30-inch OD carbon steel intermediate casing with a 12.25-inch bit to approximately 3,300 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

17. During drilling of the pilot hole collect up eight (8) cores at depths selected by the ENGINEER in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

18. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

19. Conduct up to four (4) packer tests at depths selected by the ENGINEER in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

20. Install drillable bridge plug at depth of ±2,420 feet as approved by Engineer.

21. Back-plug the pilot hole with cement to the base of the 30-inch OD carbon steel intermediate casing.

22. Ream the pilot hole to a nominal 30-inch diameter borehole to approximately 2,405 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

23. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

24. Install the 20-inch OD seamless steel final steel casing to approximately 2,400 feet bls in accordance with **Exhibit 3 – Mosaic Riverview Deep Injection Well No. 1 and Dual-Zone Monitor Well Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

25. Cement the 20-inch OD seamless steel final casing from the bottom of the casing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**. Logging may be waived by the Engineer if poor fill-up is encountered.

26. Conduct a standard cement bond log following completion of cementing of the 20-inch OD seamless steel final casing to within 300 feet of land surface in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

27. Conduct casing pressure test.

28. Cement the final ±300 feet of the 20-inch OD seamless steel final casing

29. Ream the pilot hole to a nominal 20-inch diameter borehole to approximately 3,300 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

30. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

31. Install the 10.72-inch ID Red Box 1250 FRP tubing (or approved equal) and cementing packer to approximately 2,390 feet bls with **Exhibit 3 – Mosaic Riverview Deep Injection Well No. 1 and Dual-Zone Monitor Well Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

32. Cement casing in place to within 300 feet of land surface. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

33. Conduct a standard cement bond log following required cement curing time.

34. Complete cementing of 10.72-inch ID FRP injection tubing to surface.

35. Develop the well (injection zone). Dispose of produced settled water in the discharge location at the Facility approved by the engineer of record (EOR). Purge well in accordance with FDEP SOP Protocol.

36. In accordance with FDEP SOP protocol, upon completion of development, collect background groundwater samples from the injection zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (excluding asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

37. Complete installation of wellhead fittings and valves in accordance with **Exhibit 5 – Industrial Injection Well Wellhead Completion Details**.

38. Furnish and install temporary piping, pumps, and valves to deliver clean and clear water for conducting a color video survey for the final inspection of the 10.72-inch ID Red Box 1250 FRP tubing and open hole in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

39. Conduct mechanical integrity testing of the 10.72-inch ID Red Box 1250 FRP tubing by performing a pressure test, geophysical logging (NGR, color video survey, high-resolution temperature [HRT] log and a radioactive tracer survey [RTS]) in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

40. Run a short-term injection test as approved by the FDEP UIC permit in accordance with **Exhibit 17A - Summary of Testing for Industrial Injection Well IW-1**.

41. Remove temporary steel drilling pad and install temporary barriers. Surface facilities contractor to install final concrete pad. Plug and abandon temporary shallow monitoring wells.

42. Demobilize drilling equipment, clean, and restore disturbed areas around the drilling site as directed by Engineer.

The sequential description of drilling and testing for Well IW-2 is as follows:

1. Drill a pilot hole with a 12.25-inch diameter bit to approximately 500 feet bls (below land surface) using the direct mud-rotary method. Record mechanical deviation surveys and collect rock formation samples in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2.**

2. Conduct geophysical logging [Caliper (CAL), natural gamma-ray (NGR), spontaneous potential (SP), dual-induction (DIL), borehole compensated sonic w/ variable density log (BHCS/VDL), Acoustic Borehole Imager (ABI)] in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

3. Ream the pilot hole to a nominal 50-inch diameter borehole to approximately to 425 feet bls using the direct mud-rotary method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

4. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

5. Install the 40-inch OD carbon steel surface casing (0.500-inch wall) to approximately 420 feet bls in accordance with **Exhibit 3 - Mosaic Riverview Deep Injection Well Nos. 1 and 2, and Dual-Zone Monitor Well Construction Details**, and cement to surface.

6. Conduct geophysical logging [Temperature (TEMP) and NGR after each cement stage] in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

7. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

8. Drill out cement plug and drill a pilot hole centered at the bottom of the 40-inch OD carbon steel surface casing with a 12.25-inch diameter bit to approximately 1,600 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

9. Collect up to four (4) rock cores during pilot hole drilling below the 40-inch OD carbon steel surface casing at depths selected by the ENGINEER in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

10. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, video survey (TV) or Optical Borehole Imager (OBI) or ABI, TEMP, fluid resistivity (FR) and flowmeter (FM); Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

11. Conduct up to four (4) packer tests at depths selected by the ENGINEER in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

12. Back-plug the pilot hole with cement to the base of the 40-inch OD carbon steel surface casing.

13. Ream the pilot hole to a nominal 40-inch diameter borehole to approximately 1,505 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

14. Conduct geophysical logging (CAL and NGR) in the reamed hole in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

15. Install the 30-inch OD carbon steel intermediate casing to approximately 1,500 feet bls in accordance with **Exhibit 3 – Mosaic Riverview Deep Injection Well Nos. 1 and 2 and Dual-Zone Monitor Well Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

16. Drill out cement plug and drill a pilot hole centered at the bottom of the 30-inch OD carbon steel intermediate casing with a 12.25-inch bit to approximately 3,300 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

17. During drilling of the pilot hole collect up eight (8) cores at depths selected by the Engineer in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

18. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

19. Conduct up to four (4) packer tests at depths selected by the ENGINEER in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

20. Install drillable bridge plug at depth of ±2,420 feet as approved by Engineer.

21. Back-plug the pilot hole with cement to the base of the 30-inch OD carbon steel intermediate casing.

22. Ream the pilot hole to a nominal 30-inch diameter borehole to approximately 2,405 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

23. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

24. Install the 20-inch OD seamless steel final steel casing to approximately 2,400 feet bls in accordance with **Exhibit 3 – Mosaic Riverview Deep Injection Well Nos. 1** and 2 **and Dual-Zone Monitor Well Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

25. Cement the 20-inch OD seamless steel final casing from the bottom of the casing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**. Logging may be waived by the ENGINEER if poor fill-up is encountered.

26. Conduct a standard cement bond log following completion of cementing of the 20-inch OD seamless steel final casing to within 300 feet of land surface in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

27. Conduct casing pressure test.

28. Cement the final ±300 feet of the 20-inch OD seamless steel final casing

29. Ream the pilot hole to a nominal 20-inch diameter borehole to approximately 3,300 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

30. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

31. Install the 10.72-inch ID Red Box 1250 FRP tubing (or approved equal) and cementing packer to approximately 2,390 feet bls with **Exhibit 3 – Mosaic Riverview Deep Injection Well Nos. 1 and 2 and Dual-Zone Monitor Well Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2.**

32. Cement casing in place to within 300 feet of land surface. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

33. Conduct a standard cement bond log following required cement curing time.

34. Complete cementing of 10.72-inch ID FRP injection tubing to surface.

35. Develop the well (injection zone). Dispose of produced settled water in the approved discharge location at the Facility approve by the EOR. Purge well in accordance with FDEP SOP protocol.

36. In accordance with FDEP SOP protocol, upon completion of development, collect background groundwater samples from the injection zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (excluding asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

37. Complete installation of wellhead fittings and valves in accordance with **Exhibit 5 – Industrial Injection Well Wellhead Completion Details**.

38. Furnish and install temporary piping, pumps, and valves to deliver clean and clear water for conducting a color video survey for the final inspection of the 10.72-inch ID Red Box 1250 FRP tubing and open hole in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

39. Conduct mechanical integrity testing of the 10.72-inch ID Red Box 1250 FRP tubing by performing a pressure test, geophysical logging (NGR, color video survey, high-resolution temperature [HRT] log and a radioactive tracer survey [RTS]) in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

40. Run a short-term injection test as approved by the FDEP UIC permit in accordance with **Exhibit 17B - Summary of Testing for Industrial Injection Well IW-2**.

41. Remove temporary steel drilling pad and install temporary barriers. Surface facilities contractor to install final concrete pad. Plug and abandon temporary shallow monitoring wells.

42. Demobilize drilling equipment, clean, and restore disturbed areas around the drilling site as directed by Engineer.

The following provides a chronological description of the construction, well drilling, and testing activities associated with the construction of DZMW-1. **Exhibit 17C** provides a Summary of Testing to be conducted during construction activities. The final design of the DZMW will be contingent upon the results of IW-1, IW-2, and DZMW-1 drilling, geophysical logging, water quality and hydrogeologic testing.

1. Excavate fill materials and install a 24-inch OD (0.375-inch wall) carbon steel pit casing to the depth required for the drilling system. The pit casing shall be installed as needed to stabilize the site for drilling at the location of the MWs. Excavated materials shall be stockpiled onsite at the location designated by Mosaic.

2. Construct a temporary fabricated steel (or equal) fluid containment pad. The drilling contractor shall provide containment pad details for information.

3. Install 4-inch diameter PVC shallow PMWs at locations approved by the FDEP. PMW locations are shown in **Exhibit 2A** and **2B** and PMW construction details are show in **Exhibit 4**. NELAP certified laboratory shall collect and analyze background water samples for analysis.

4. Mobilize and set up drilling equipment at the MW sites.

5. Drill a nominal 12.25-inch diameter pilot hole using the direct mud-rotary drilling method to approximately 425 feet bls, record mechanical deviation surveys and collect rock formation samples at intervals in accordance with **Exhibit 17C – DZMW Summary of Testing**.

6. Conduct geophysical logging in accordance with **Exhibit 17C – DZMW Summary of Testing** (CAL, NGR, SP, DIL, BHCS w/ VDL, ABI).

7. Ream pilot hole to nominal 24-inch diameter borehole using the direct mud-rotary drilling method to the 16-inch OD seamless steel casing setting depth of approximately 405 feet bls and record mechanical deviation surveys at intervals in accordance with **Exhibit 17C – DZMW Summary of Testing**.

8. Conduct geophysical logging in accordance with **Exhibit 17C – DZMW Summary of Testing** (CAL and NGR log).

9. Install approximately 400 feet of 16-inch OD (0.500-inch wall) seamless steel casing and perform the first CBL log on the uncemented casing. Cement with ASTM C-150 Type II or Type 1L cement to approximately 200 feet bls. After each cement stage, perform hard tags, Temperature and NGR logs. Perform the second CBL on the 16-inch OD cemented casing. Cement the remaining annulus to surface using ASTM C-150 Type II or Type 1L cement.

10. Once the cement has cured perform a casing pressure test in accordance with **Exhibit 17C – DZMW Summary of Testing**.

11. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

12. Drill out cement plug and drill a nominal 12.25-inch diameter hole centered at the bottom of the 16-inch OD seamless steel casing to approximately 900 feet bls using reverse-air circulation. Record mechanical deviation surveys, collect rock/water formation samples and analyze air-lifted water samples during reverse-air drilling in accordance with **Exhibit 17C – DZMW Summary of Testing**.

13. Conduct static geophysical logging on the 12.25-inch diameter pilot hole to an approximate depth of 900 feet bls in accordance with **Exhibit 17C – DZMW Summary of Testing** (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV, TEMP, FR and FM; Dynamic logs: TEMP, FR and FM).

14. Conduct dynamic geophysical logging on the pilot hole to an approximate depth of 900 feet bls in accordance with **Exhibit 17C – DZMW Summary of Testing** while flowing or pumping the well at approximately 500 gpm. Perform the following dynamic logs: Temperature, Flow Meter, Flow Meter Interpretation, Fluid Resistivity, and TV survey (or BHTV).

15. Conduct up to two (2) packer tests in the pilot hole between approximately 400 feet and 800 feet bls in accordance with **Exhibit 17C – DZMW Summary of Testing**. Collect and analyze (NELAP-Certified laboratory) groundwater samples during packer testing to confirm the water quality of the UMZ and LMZ.

16. Install approximately 800 feet of 6.21-inch ID FRP tubing with attached external cementing packer. Cement approximately 300 feet of the bottom of 6.21-inch ID FRP tubing using ASTM C-150 Type II or Type 1L cement. Cement placement will be accomplished using tremie pipe.

The top of the 6.21-inch ID FRP tubing cement fill-up will be at a depth of approximately 500 feet bls. An open-hole annular monitoring zone shall be provided from the top of the 6.21-inch ID FRP tubing cement to 100 feet below (approximately 400 feet bls) the bottom of the 16-inch OD seamless steel casing. After each cement stage, perform hard tags, Temperature and NGR to confirm the top of the annular cement. Once the cement has cured perform a casing pressure test (50 PSI for one hour) in accordance **Exhibit 17C – DZMW Summary of Testing**.

17. Conduct CBL in accordance with **Exhibit 17C – DZMW Summary of Testing**.

18. Install temporary wellhead appurtenances, and after the cement has cured, perform casing pressure test (minimum 50 psi) for one hour on the 6.21-inch ID FRP tubing using an inflatable down-hole packer in accordance with **Exhibit 17C – DZMW Summary of Testing**.

19. Develop both monitoring zones by pumping and/or air-lift methods to obtain the maximum measured specific capacity for each monitoring zone in accordance with **Exhibit 17C – DZMW Summary of Testing**. Pump (or flow if rate is adequate) each monitoring zone a minimum of 10 volumes or until temperature, chlorides and specific conductivity stabilize in accordance with FDEP SOP protocol. Upon completion of purging, collect a groundwater sample from each completed monitoring zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (excluding asbestos and dioxin) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

20. Perform final inspection of 6.21-inch ID FRP tubing by running a CAL log (open-hole only) and TV survey while flowing or pumping the 6.21-inch ID FRP tubing in accordance with **Exhibit 17C – DZMW Summary of Testing**. Discharge produced settled water in the discharge location at the Facility approved by the EOR.

21. Install temporary wellhead assembly and appurtenances in accordance with **Exhibit 5 – Temporary Wellhead Drawings**.

22. Install temporary pressure transducer in each monitoring zone (UMZ and LMZ) of the MW for measurement of artesian head (elevation) during pre-injection test background period, injection testing, and recovery periods (pending FDEP approval).

15. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

Financial assurance is discussed in Section 4.1. Mosaic will be using the financial test to demonstrate financial assurance, as required by Rule 62-528.435(9), F.A.C. The Engineer's cost estimate for P&A of the IW System, and DZMW-1 is provided in **Exhibits 18A**. The P&A Plan for IW-1, IW-2, and DZMW-1 are discussed in Section 4.2 and details are provided in Exhibit **18B** for IW-1, **Exhibit 19C** for IW-2, and **Exhibit 18D** for DZMW-1.

4.0 Injection Well System Financial Assurance, Documentation and Well Plugging Cost Estimates

(Responses to Part A, Number 15 of Form 62-528.900(1))

4.1 Financial Assurance and Documentation

Mosaic certifies that it has the necessary resources available to plug and abandon (P&A) the IW System and Well DZMW-1, should this action be required. Mosaic will be using the financial test to demonstrate financial assurance, as required by Rule 62-528.435(9), F.A.C.

4.2 Abandonment Plan for IW System and DZMW-1

This P&A plan outlines the procedures and cost for P&A of the IW System to a depth of 3,300 feet bls and of DZMW-1 to a depth of 800 feet bls located at the Facility. If the injection well system must be abandoned, the injection zone/monitoring zones must be effectively plugged and sealed to prevent the upward migration of fluid from the injection zone and/or an interchange of formation water between aquifers. The P&A opinion of costs are provided in **Exhibit 18A** and Abandonment Details are provided in **Exhibits 18B, 18C** and **18D**.

This P&A plan describes a procedure for plugging and sealing the IW System and both monitoring zones of DZMW-1 using gravel and cement. Gravel will be used to fill in the injection zone up to 10 feet below the base of the FRP tubing. The 17.98-inch ID FRP injection tubing is then plugged with cement from above the gravel top to land surface. For DZMW-1, each monitoring zone is filled with gravel in the open borehole and cemented to land surface.

The following is a sequence of gravel and cement sealing of 1) the injection zone and 2) of the UMZ and LMZ. The cost calculations allow for the purchase of all the materials and services necessary for well abandonment tasks and represent the approximate cost for P&A of the IW System, including a 10% contingency and estimated associated oversight for engineering costs of 20%.

As presented in **Exhibits 18B and 18C**, the materials quantities and services provided to plug the IWs will proceed as follows:

1) Mobilize drill rig, kill the well by filling the cemented 10.72-inch ID FRP injection tubing with weighted drilling mud or salt, and remove the valve assembly and appurtenances from the wellhead. Conduct geophysical logging.

2) Add a volume of crushed limestone to the well equal to the volume of the open hole section of Well IW-1 to fill the open formation to approximately 10 feet below the bottom of the 10.72-inch ID FRP injection tubing. Verify the depth to the top of the crushed limestone by tagging with a wireline. Place neat cement in stages into the 10.72-inch ID FRP injection tubing through a tremie pipe to the top of the crushed limestone. The quantity of cement pumped above the top of the gravel should be equivalent to the volume of slurry required to fill approximately 10 feet of open hole and the entire length of 10.72-inch ID FRP injection tubing.

3) The cement should be allowed to set for 12 to 24 hours and then hard tagged with a wire line or tremie pipe to determine if sufficient fill up has been achieved.

4) The remainder of the 10.72-inch ID FRP injection tubing can then be filled with neat cement using the tremie method to land surface.

The UMZ and LMZ of the DZMW will be plugged by filling the open-hole portion of each zone with gravel and pumping cement to land surface in stages. The LMZ will be abandoned first followed by the UMZ. As presented in **Exhibit 18E**, the proposed plan to abandon the DZMW lower and upper zones by gravel and cement method will proceed as follows:

1) Mobilize a drill rig and kill the well by partially filling the 6.21-inch ID FRP tubing of the LMZ with a dense saltwater solution. Remove the wellhead flanges and appurtenances from the well. Conduct geophysical logging.

2) Add a volume of gravel to the well equal to the volume of the open-hole sections of the monitoring zones. Fill the open-hole with gravel to approximately 10 feet below the bottom of each casing (to 710 feet bls within the 6.21-inch ID FRP tubing and to 430 feet bls within the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD seamless steel casing). Verify the depth to gravel placement by hard tagging the gravel top in both zones with a wire-line or tremie pipe.

3) For the LMZ, pump neat cement on top of the gravel placed in the 6.21-inch ID FRP tubing. For the UMZ, pump neat cement on top of the gravel through a tremie pipe placed in the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD seamless steel casing. Fill the casings with the neat cement slurry in stages to land surface.

4) Verify the depth of each stage by hard tagging the cement top with a wire line or tremie pipe.

5) Complete below ground and add monument.

5.0 References

Applin, P.L. and Applin, E.R, *Regional Subsurface Stratigraphy and Structure of Florida and Southern Georgia*, AAPG Bulletin, Volume 28, Issue 12, December 1944.

Arthur, J.D., *Petrogenesis of Early Mesozoic Tholeiite in the Florida Basement and an Overview of Florida Basement Geology*, Report of Investigations no. 97, Florida Geological Survey, 1988; https://ufdc.ufl.edu/UF00001284/00001/images/10

Arthur, J. D., Fischler, C., Kromhout, C., Clayton, J. M., Kelley, G. M., Lee, R. A., LiLi, O'Sullivan, M., Green, R.C. and Werner, C.L., 2008, Hydrogeologic Framework of the Southwest Florida Water Management District, Florida Geological Survey, Bulletin No. 68.https://resourcespace.dep.state.fl.us/pages/view.php?search=%21last1000&k=&modal=&display=strip&order_by=field3&offset=635&per_page=120&archive=&sort=ASC&restypes=&recentdaylimit=&foredit=&ref=13323

ASRus. LLC. (2023). (rep.). Construction and Testing of the Manatee County Piney Point Injection Well IW-1 and Monitoring Well DZMW-1 (Vol. Permit No. 0322708-002-UC/1l, Ser. WACS ID No. 101607, pp. Appendix I). Tampa, Florida.

Ceryak, R., Knapp, M. S., and Burnson, T., 1983. *The Geology and Water Resources of the Upper Suwannee River Basin, Florida* - Florida Department of Natural Resources, Bureau of Geology, Report of Investigation No. 87. https://ufdc.ufl.edu/UF00001274/00001/images/0

Dallmeyer, R.D., A *Tectonic Linkage between the Rodelide Orogen (Sierra Leone) and the St. Lucie Metamorphic Complex in the Florida Subsurface*, The Journal of Geology, v. 97, no. 2, March 1989. https://www.journals.uchicago.edu/doi/abs/10.1086/629293

Florida Department of Environmental Protection (1990, January 1). *Underground Injection Control Monitoring Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved March 2, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-monitoring-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (2009, March 1). *Underground Injection Control (UIC) Class V ASR Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved March 2, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-uic-class-v-asr-wells/explore?location=27.891589%2C-83.466600%2C5.97

FDEP. (2018, June 5). Well W-7572 (U.S. Phosph. Prod.- Well #38) Borehole Description Summary. Florida Department of Environmental Protection. Retrieved April 25, 2023, from https://geodes.kyrasolutions.com/BoreholeSummary/InventoryWell/7572

South Florida Water Management District Open Data. (n.d.). https://geo-sfwmd.hub.arcgis.com/

DBHYDRO Wells and Boreholes. (n.d.). https://geo-sfwmd.hub.arcgis.com/datasets/dbhydro-wells-and-boreholes/explore

FGS Geologic Data | Florida Department of Environmental Protection. (n.d.). https://floridadep.gov/fgs/data-maps/content/fgs-geologic-data

Water Resources of the United States—National Water Information System (NWIS) Mapper. (n.d.). https://maps.waterdata.usgs.gov/mapper/index.html

Wells Permitted by Lee County. (n.d.). https://maps.leegov.com/datasets/wells-permitted-by-lee-county/explore

Miller, J. A., 1986, *Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina*, U.S. Geological Survey Professional Paper 1403B. https://pubs.er.usgs.gov/publication/pp1403B

Milton, C., Igneous and Metamorphic Basement Rocks of Florida, Bulletin 55, Florida Bureau of Geology, 1972. https://original-ufdc.uflib.ufl.edu/UF00000245/00001

Mouring, S. E., Janowski, M.-E., Louca, L. A., & Brambleby, R. J. (2013, June 30). *Behavior of Hybrid Protruded Steel-to-Fiber Reinforced Polymer Joints.* International Society of Offshore and Polar Engineers.*http://publications.isope.org/proceedings/ISOPE/ISOPE%202013/papers/vol4/13TPC-1139Mouring-.pdf*

Puri and Vernon, 1974; Geologic Framework of the High Transmissivity Zones in South Florida, Bureau of Geology, Special Publication No. 20, 101 p. https://original-ufdc.uflib.ufl.edu/UF00000159/00001

Reese, R. S. (1994). *Hydrogeology and the distribution and origin of salinity in the Floridan Aquifer System, Southeastern Florida*. Water-Resources Investigations Report. Retrieved March 6, 2023, from https://pubs.er.usgs.gov/publication/wri944010

Reese, R. S. and Richardson E., *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida, U.S. Geological Survey Scientific Investigations Report 2007-5207*, 2007. https://pubs.usgs.gov/sir/2007/5207/

Scott, T.M., 1988. *The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Florida Geological Survey*, Bulletin 59, 148 p.

Scott, 1992, *A Geological Overview of Florida,* Florida Geological Survey, Open File Report No. 50, 81 p. https://resourcespace.dep.state.fl.us/pages/view.php?search=%21last1000&k=&modal=&display=thumbs&order_by=resourcetype&offset=380&per_page=240&archive=&sort=DESC&restypes=&recentdaylimit=&foredit=&ref=13571

Scott, T. M., *The Geologic Map of Florida (and Accompanying Text)*, Florida Geological Survey Open-File Report 80, 2001. https://ufdcimages.uflib.ufl.edu/UF/00/09/40/41/00001/OFR80.pdf

Williams, L.J., and Kuniansky, E.L., 2016, *Revised hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina* (ver. 1.1, March 2016): U.S. Geological Survey Professional Paper 1807, 140 p., 23 pls., http://dx.doi.org/10.3133/pp1807.

Submitted via Electronic Mail

February 16, 2024

Ronald McCulley
Florida Department of Environmental Protection
2600 Blair Stone Road MS 3500
Tallahassee, Florida 32399

Mosaic Fertilizer, LLC – New Wales Facility
Initial Application to Construct Class V Exploratory Injection Well
Polk County

Dear Mr. McCulley:

Please find attached herein an application for the Mosaic Fertilizer, LLC (Mosaic) New Wales Facility (Facility) for construction of a proposed Class V Exploratory Injection Well. The proposed exploratory well will be installed at the New Wales facility located within Polk County and will consist of the construction of one proposed exploratory injection well. Included with this package is a signed and sealed copy of FDEP Form 62-528.900(1). Check No. 203429 in the amount of $750.00 will be mailed separately to the Department to support the associated permit processing fee.

Mosaic has included the "Mosaic New Wales Facility Exploratory Well IW-1 Class V, Group 9, Exploratory Injection Well Construction Permit Application" which was prepared by our third-party consultant, Black & Veatch. This report provides the supporting information as required in the Florida Department of Environmental Protection (FDEP) Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems*. This application also previews information that will be submitted at a later date to potentially submit a Class I Well Construction Permit for the Facility utilizing information collected during the construction of the proposed Class V Exploratory Injection Well.

If you have any questions or require any additional information to assist in the review of this application, please contact me at (813) 541.4633 or by email at ben.koplin@mosaicco.com.

Sincerely,

Ben L Koplin
Sr Manager, Environmental

Encl: FDEP Form 62-528.900(1)
Delegation of Authority – Mr. Nevin Maga
Mosaic New Wales Facility Exploratory Well IW-1 Class V, Group 9, Exploratory Injection Well Construction Permit Application

cc: John Coates, FDEP
Pat Kane, Mosaic
Nevin Maga, Mosaic
Santino Provenzano, Mosaic
John Allen, Mosaic
Monica Tochor, Mosaic
Jackie Barron, Mosaic

MOSAIC NEW WALES FACILITY EXPLORATORY WELL IW-1

Florida Department of Environmental Protection Class V, Group 9, Exploratory Injection Well Construction Permit Application

B&V PROJECT NO. 417412

PREPARED FOR

Mosaic Fertilizer, LLC

16 FEBRUARY 2024

BLACK & VEATCH

CERTIFICATIONS

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

PROFESSIONAL ENGINEER

The engineering features of the Class V, Group 9, Exploratory Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, February 2024, were prepared by, or reviewed by, a Licensed Professional Engineer in the State of Florida.

Jon Dinges, P.E.

2/16/2024

Date

PE54747

License No.

JON MICHAEL DINGES
LICENSE
No. 54747
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the Class V, Group 9, Exploratory Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, February 2024, were prepared by, or reviewed by, a Licensed Professional Geologist in the State of Florida.

Ed Rectenwald, P.G.

2/16/2024

Date

PG2469

License No.

E. EDWARD RECTENWALD
LICENSE
No. PG2469
STATE OF
FLORIDA
PROFESSIONAL GEOLOGIST

Table of Contents

LIST OF TABLES

LIST OF EXHIBITS

LIST OF ACRONYMS AND ABBREVIATIONS

ASR	Aquifer Storage and Recovery
AOR	Area of Review
APPZ	Avon Park Permeable Zone
ASTM	American Society for Testing and Materials
BHCS	Borehole Compensated Sonic Log
bls	below land surface
BZ	Boulder Zone
CAL	Caliper Log
CBL	Cement Bond Log
DIL	Dual Induction Log
DZMW	Dual-Zone Monitoring Well
EOR	Engineer of Record
FAS	Floridan Aquifer System
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FGS	Florida Geological Survey
FM	Flowmeter Log
FR	Fluid Resistivity Log
FRP	Fiberglass Reinforced Plastic
ft	Feet
feet/min	Feet per minute
feet/sec	Feet per second
gpm	Gallons per minute
HRT	High Resolution Temperature Log
ICU	intermediate confining unit
ID	Inside diameter
IW	Injection Well
LCPZ	Lower Cretaceous Permeable Zone
LFA	Lower Floridan aquifer
LMZ	Lower Monitoring Zone
MCU	Middle Confining Unit
MGD	Million gallons per day
mg/L	Milligrams per Liter
MIT	Mechanical Integrity Testing
NAVD	North American Vertical Datum
NELAP	National Environmental Laboratory Accreditation Program
NGR	Natural Gamma Ray Log
NGVD	National Geodetic Vertical Datum
OD	Outside diameter
P&A	Plugging and Abandonment
PMW	Pad Monitoring Well
psi	Pounds per Square Inch
PVC	Polyvinyl chloride
RTS	Radioactive Tracer Survey
SAS	Surficial Aquifer System
SFCU	Sub-Floridan Confining Unit

SFWMD	South Florida Water Management District
SOP	Standard Operating Procedures
SP	Spontaneous Potential Log
SWFWMD	Southwest Florida Water Management District
TEMP	Temperature Log
TD	Total Depth
TDS	Total Dissolved Solids
TV	Color Video Survey
UCPZ	Upper Cretaceous Permeable Zone
UFA	Upper Floridan aquifer
UIC	Underground Injection Control
UMZ	Upper Monitoring Zone
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
VDL	Variable Density Log
WWTF	Wastewater Treatment Facility

Permit Application and Documentation Format

The information required in FDEP Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems* is included herein and is divided into the following sections:

Section 1 - FDEP Form No. 62-528.900(1) Application to Construct/Operate/Abandon Class V Well Systems. The executed Class V Exploratory Well Construction and Testing Permit application is contained in this section and addresses the specific information requested in Application Form 62-528.900(1).

Section 2 - Class V Exploratory Well Construction Supporting Data and Part F Responses to Part F of Form 62-528.900(1).

Section 3 - Supplemental Information for Future Class I Industrial Well Construction Permit Application. Section 3 provides additional information not specifically required for the Class V Exploratory Well Construction Permit. This is a preview of information that will be submitted at a later date for the Class I Well Construction Permit application and is provided here only as general information to help with expediting the Class V Well Construction Permit application review.

All project well schematics and figures are included in the Exhibits.

1.0 FDEP Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems

FDEP Rule No. 62- 528.900(1)] Forms for Underground Injection Control

Florida Department of Environmental Protection

Twin Towers Office Bldg., 2600 Blair Stone Road, Tallahassee, Florida 32399-2400

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No,:	
WACS#	(Filled in by DEP)

APPLICATION TO CONSTRUCT/OPERATE/ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

Part I. Directions

A. All applicable items must be completed in full in order to avoid delay in processing this application. Where attached sheets or other technical documentation are utilized in lieu of the blank space provided, indicate appropriate cross-reference in the space and provide copies to the Department in accordance with C. below. Where certain items do not appear applicable to the project, indicate N/A in the appropriate spaces.

B. All information is to be typed or printed in ink.

C. Two (2) copies of this application and two (2) copies of supporting information such as plans, reports, drawings and other documents shall be submitted to the appropriate Department office if submitted as a paper document, or one (1) copy of the application and one (1) copy of the plans, reports, drawings and other documents if the submittal is in an electronic format. An engineering report is also required to be submitted to support this application pursuant to the applicable sections of Rule 62-528, F.A.C. The attached list* shall be used to determine completeness of supporting data submitted or previously received. A check for the application fee in accordance with Rule 62-4.050, F.A.C., made payable to the Department shall accompany the application.

D. For projects involving construction, this application is to be accompanied by two (2) sets or one (1) set, in accordance with C. above, of engineering drawings, specifications and design data as prepared by a Professional Engineer registered in Florida, where required by Chapter 471, Florida Statutes.

E. Attach 8 1/2" x 11" site location map indicating township, range and section and latitude/longitude for the project.

PART II. General Information

A. Applicant Name Nevin Maga Title General Manager - New Wales

Address 13830 Circa Crossing Drive

City Lithia State Florida Zip 33547

Telephone Number 813-775-4838 Email Nevin.maga@mosaicco.com

B. Project Status: ☑ New ☐ Existing

☐ Modification (specify) N/A

*"Engineering and Hydrogeologic Data Required for Support of Application to Construct, Operate and Abandon Class I, III, or V Injection Wells"

C. Well Type: ☑ Exploratory Well ☐ Test/Injection Well

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: .
DEP Application No,: .
WACS# (Filled in by DEP)

D. Type of Permit Application

- ☐ Class I Test/Injection Well Construction and Testing Permit
- ☐ Class I Well Operation Permit
- ☐ Class I Well Operation Repermitting
- ☐ Class I Well Plugging and Abandonment Permit
- ☐ Class III Well Construction/Operation/Plugging and Abandonment Permit
- ☑ Class V Exploratory Well Construction and testing Permit
- ☐ Class V Well Construction Permit
- ☐ Class V Well Operation Permit
- ☐ Class V Well Plugging and Abandonment Permit
- ☐ Monitor Well Only

E. Facility Identification:

Name Mosaic New Wales Facility

Facility Location: Street 3095 Highway 640

City Mulberry County Polk County

SIC Code(s) 2874

F. Proposed facility located on Indian Lands: Yes ☐ No ☑

G. Well Identification:

Well No. IW-1 of 1 (total #) Wells *Multiple wells may be noted*

Purpose (Proposed Use) Injection of Pre-Treated, non-hazardous Process Water from the New Wales Facility

Well Location: Latitude: See ° App ' Docs " Longitude: See ° App ' Docs "
(attach separate sheet(s), if necessary, for multiple wells)

Subpart B. General Project Description:

H. General Project Description: Describe the nature, extent and schedule of the injection well project. Refer to existing and/or future pollution control facilities, expected improvement in performance of the facilities and state whether the project will result in full compliance with the requirements of Chapter 403, F.S., and all rules of the Department. Attach additional sheet(s) if necessary or cross-reference the engineering report.

The proposed Exploratory Injection Well (IW-1) has been designed for the injection of treated, non-hazardous industrial wastewater stored in the Mosaic New Wales (FDEP Wastewater Permit FL0036421 and FL0178527) phosphogypsum stacks (gyp-stacks), the phreatic water collected by the gypstack underdrain system, and recovery well water. During construction of IW-1, the local hydrogeology will be investigated to confirm the properties of the target injection zone (Upper Cretaceous Permeable Zone) as compatible for injection fo pre-treated wastewater from the Facility.

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PART III. Statement by Applicant and Engineer

A. Applicant

I, the owner/authorized representative* of Mosaic Fertilizer, LLC certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I understand that this certification also applies to all subsequent reports submitted pursuant to this permit. Where construction is involved, I agree to retain the design engineer, or other professional engineer registered in Florida, to provide inspection of construction in accordance with Rule 62-528.455(1)(c), F.A.C.

______ Signed | FEB 13 2024 Date

Nevin Maga - General Manager - New Wales
Name and Title (Please Type)

813-775-4838
Telephone Number

*Attach a Letter of Authorization.

B. Professional Engineer Registered in Florida

This is to certify that the engineering features of this injection well have been designed/examined by me and found to be in conformity with modern engineering principles applicable to the disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgement, that the well, when properly maintained and operated, will discharge the effluent in compliance with all applicable statutes of the State of Florida and the rules of the Department. It is also agreed that the undersigned will furnish the applicant a set of instructions for proper maintenance and operation of the well or ensure they have been furnished.

JON MICHAEL DINGES
LICENSE
No. 54747
STATE OF FLORIDA
PROFESSIONAL ENGINEER

(Please Affix Seal)

______
Signed

Jon M. Dinges
Name (Please Type)

Black & Veatch
Company Name (Please Type)

1715 N. Westshore Boulevard, Suite 725, Tampa, FL 33607
Mailing Address (Please Type)

Florida Registration No. PE No. 54747 Date 2/16/2024 Phone No. 386-361-5374

Email of P.E.: DingesJ@bv.com

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ENGINEERING AND HYDROLOGIC DATA REQUIRED FOR SUPPORT OF APPLICATION TO CONSTRUCT, OPERATE, AND ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

The following information shall be provided for each type of permit application.

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data.

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program.

15. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

B. CLASS I INJECTION WELL OPERATION PERMIT

1. A report shall be submitted with each application for a Class I Well operating permit, which shall include, but not be limited to, the following information:

   (a) Results of the information obtained under the construction permit described in A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT, including:

      (1) All available logging and testing program data and construction data on the well or well field;

      (2) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C;

      (3) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

      (4) The actual injection procedure;

      (5) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone; and,

      (6) The status of corrective action on defective wells in the area of review.

   (b) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

   (c) Certification of completion submitted by the engineer of record;

   (d) If requested by the Department, operation manual including emergency procedures;

   (e) Proposed monitoring program and data to be submitted;

(f) Proof that the existence of the well has been recorded on the surveyor's plan at the county courthouse; and,

(g) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

C. CLASS I WELL OPERATION REPERMITTING

1. An updated map showing the location of the injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of pubic record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the injection zone, confining zone, or monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

7. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

8. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

9. A report shall be submitted with each application for repermitting of Class I Well operation which shall include the following information:

   (a) All available logging and testing program data and construction data on the well or well field;

(b) A satisfactory demonstration of mechanical integrity for all wells pursuant to Rule 62-528.300(6), F.A.C.;

(c) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

(d) The actual injection procedure;

(e) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone;

(f) The status of corrective actin on defective wells in the area of review;

(g) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

(h) Certification of completion submitted by the engineer of record;

(i) An updated operation manual including emergency procedures;

(j) Proposed revisions to the monitoring program or data to be submitted; and,

(k) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

D. CLASS I WELL PLUGGING AND ABANDONMENT PERMIT

1. The reasons for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods, and justification for use.

    (a) The type and number of plugs to be used;

    (b) The placement of each plug including the elevation of the top and bottom;

    (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

    (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

E. CLASS III WELLS CONSTRUCTION/OPERATION/PLUGGING AND ABANDONMENT PERMIT

Construction Phase

1. A map showing the location of the proposed injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water system, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data:

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids, including any additives.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures or catastrophic collapse, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, and a drilling, testing and coring program.

15. A certificate that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

16. Expected changes in pressure, native fluid displacement, direction of movement of injection fluid.

17. A proposed monitoring plan, which includes a plan for detecting migration of fluids into underground sources of drinking water, a plan to detect water quality violation in the monitoring wells, and the proposed monitoring data to be submitted.

Operation Phase

1. The following information shall be provided to the Department prior to granting approval for the operation of the well or well field:

   (a) All available logging and testing program data and construction data on the well or well field;

   (b) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C.;

   (c) The actual operating data, including injection pressure versus pumping rate where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

   (d) The results of the formation testing program;

   (e) The actual injection procedure; and,

   (f) The status of corrective action on defective wells in the area of review.

Plugging and abandonment Phase

1. The justification for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT

1. Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.

2. Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

3. Proposed other uses of the exploratory well.

4. Drilling and testing plan for the exploratory well. The drilling plan must specify the proposed drilling program, sampling, coring, and testing procedures.

5. Abandonment Plan.

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G. CLASS V WELL CONSTRUCTION PERMIT

(This form should be used for Class V Wells instead of Form 62-528.900(3), F.A.C., when there is a need for a Technical Advisory Committee and an engineering report.)

1. Type and number of proposed Class V Wells:

________ Wells Receiving Domestic Waste

________ Desalination Process Concentrate Wells (Reverse Osmosis, etc.)

________ Aquifer Storage and Recovery Wells

________ Aquifer Remediation Wells

________ Salt-water Intrusion Barrier Wells

________ Cooling Water Return Flow Wells Open-looped System

________ Subsidence Control Wells

________ Aquifer Recharge Wells

________ Experimental Technology Wells

________ Wells used to inject spent brine after halogen recovery

________ Radioactive Waste Disposal Wells*

________ Borehole Slurry Mining Wells

________ Other non-hazardous Industrial or Commercial Disposal Wells

(explain) ____

________ Other (explain) ____

*Provided the concentrations of the waste do not exceed drinking water standards contained in Chapter 62-550, F.A.C.

2. Project Description:

   (a) Description and use of proposed injection system;

   (b) Nature and volume of injected fluid (the Department may require an analysis including bacteriological analysis) in accordance with Rule 62-528.635(2)(b), F.A.C.; and,

   (c) Proposed pretreatment.

3. Water well contractor’s name, title, state license number, address, phone number and signature.

4. Well Design and Construction Details. (For multi-casing configurations or unusual construction provisions, an elevation drawing of the proposed well should be attached.)

   (a) Proposed total depth;

   (b) Proposed depth and type of casing(s);

   (c) Diameter of well;

   (d) Cement type, depth, thickness; and,

   (e) Injection pumps (if applicable): ________________ gpm @ ________________ psi

   Controls: ____
   ____
   ____

5. Water Supply Wells - When required by Rule 62-528.635(1), F.A.C., attach a map section showing the locations of all water supply wells within a one-half (1/2) mile radius of the proposed well. The well depths and casing depths should be included. When required by Rule 62-528.635(2), F.A.C., results of bacteriological examinations of water from all water supply wells within one-half (1/2) mile and drilled to approximate depth of proposed well should be attached.

6. Area of review (When required by Rule 62-528.300(4), F.A.C.)

   Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

H. CLASS V WELL OPERATION PERMIT

(Final report of the construction that includes the following information may be submitted with the application to operate.)

1. Permit Number of Class V Construction Permit: ________________________________

2. Owner's Name: ____

3. Type of Wells: ____

4. Construction and Testing Summary:

(a) Actual Dimensions:

Diameter		Well Depth		Casing Depth	
	______ (inches)		______ (feet)		______ (feet)
	______		______		______
	______		______		______
	______		______		______
	______		______		______

(b) Result of Initial Testing

5. Proposed Operating Data:

(a) Injection Rate (GPM);

(b) Description of injected waste; and,

(c) Injection pressure and pump controls.

6. Proposed Monitoring Plan (if any):

(a) Number of monitoring wells;

(b) Depth(s);

(c) Parameters;

(d) Frequency of sampling; and,

(e) Instrumentation (if applicable) Flow ______

Pressure ______

I. CLASS V WELLS PLUGGING AND ABANDONMENT PERMIT

1. Permit number of Class V construction or operating permit.

2. Type of well.

3. Proposed plugging procedures, plans and specifications.

4. Reasons for abandonment.

J. MONITOR WELL PERMIT

This section should be used only when application is made for a monitor well only. If a monitor well is to be constructed under a Class I, III, or V injection well permit, it is not necessary to fill in this section.

1. A site map showing the location of the proposed monitor wells for which a permit is sought. The map must be to scale and show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, water wells and other pertinent surface features including structures and roads.

2. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

3. Maps and cross sections detailing the hydrology and geologic structures of the local area.

4. Generalized maps and cross sections illustrating the regional geologic setting.

5. Proposed formation testing program to obtain an anlysis of the chemical, physical and radiological characteristics of and other information on the monitor zone(s).

6. Proposed monitoring procedure.

7. Engineering drawings of the surface and subsurface construction details of the monitoring system.

8. Proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

9. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program

10. Monitor Well Information:

    ☐ On-site ☐ Multizone ☐ Single-zone

    ☐ Regional ☐ Other (specify) ______________________________

    Proposed Monitoring Interval(s) ______________________________

    Distance and Direction From Associated Injection Well

    ____

CERTIFICATE OF OFFICER OF MOSAIC FERTILIZER, LLC AS TO AUTHORIZATION

The undersigned, Kelly J. Strong, does hereby certify that he is the duly elected Vice President – Operations, Mining North America of Mosaic Fertilizer, LLC, a Delaware limited liability company (the "Company") and further certifies as follows:

1. Nevin G. Maga, in his capacity as General Manager – New Wales for the Company, is authorized to execute and submit all routine environmental reports, permit applications and follow-up responses, where the signature of an officer is not otherwise mandated by law, statute, or regulation.

2. The signature appearing opposite Mr. Maga's name is a true and correct specimen of his signature:

NAME:	TITLE:	SIGNATURE:
Nevin G. Maga	General Manager – New Wales	[signature]

In witness whereof, the undersigned has executed this document effective this 16 day of October, 2023.

[signature]

Kelly J. Strong
Vice President – Operations, Mining North America

IRINA MARIE GALEONE
Notary Public - State of Florida
Commission # HH 340649
My Comm. Expires Dec 12, 2026

Subscribed and sworn to before me this 16 day of October 2023.

[signature]

Notary Public

2.0 Class V Exploratory Well Construction Permit Supporting Data

(Responses to Part F of Form 62-528.900(1))

The following addresses the information specifically required in FDEP UIC permit application (FDEP Form 62-528.900(1)), page 10, Section F "EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT". The permit application required information is shown in **bold** type followed by the supporting technical information.

F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT

1. **Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.**

Injection Well Hydraulic Design Criteria

The proposed Exploratory Injection Well (IW-1) has been designed for the injection of pre-treated, non-hazardous industrial wastewater from the Mosaic Fertilizer, LLC (Mosaic) New Wales facility's (Facility) (FDEP Wastewater Permits FL0036421 and FL0178527) phosphogypsum stack system (gypstack), the phreatic water collected by the gypstack underdrain system, recovery well water, and associated pre-treated process water(s). The phreatic water, or gypsum stack pore water, collected in the underdrain system is not considered a separate waste stream and is characteristically similar to ponded process water. The water collected in the underdrain system is returned to the gypstack and will be comingled with the process water that will go through pre-treatment. The Facility recovers water from a number of recovery wells to capture constituents and contain impacts onsite. Recovery well volumes, when operational, range from 3,800 gpm to 4,200 gpm. The constituent of concern in the recovered volumes is total dissolved solids. The concentration of other constituents in the recovery wells are below the limits of EPA's primary and secondary drinking water standards.

During construction of Well IW-1, the local hydrogeology will be investigated to confirm the properties of the target injection zone (Upper Cretaceous Permeable Zone [UCPZ]) as compatible for injection of pre-treated wastewater from the Facility. The location of the Facility is shown in **Exhibit 1**. The proposed locations for Exploratory Well IW-1 at the Facility is shown in **Exhibit 2**.

As shown in **Exhibit 3**, the injection well will be constructed with a 20-inch outside diameter (OD), 0.500-inch wall, final seamless steel casing. A nominal 10.72-inch inside diameter (ID) RedBox 1250 FRP injection tubing with a packer assembly will be installed and cemented inside the 20-inch OD final seamless steel casing. In accordance with fluid velocity limitations for the injection well, the design injection capacity is approximately 2,775 gallons per minute (gpm) (or 4.00 Million Gallons per Day [MGD]) at 10 feet per second (ft/sec). The proposed injection well system will include a dual-zone monitoring well (DZMW-1) for continuous monitoring of the hydraulic head and water quality within two completed monitoring zones, above and below the underground source of drinking water (USDW).

Following construction and provided the testing of IW-1 and DZMW-1 is favorable, Mosaic expects to seek to re-classify the exploratory well to a UIC Class I industrial injection well for operational testing. The Class I well will facilitate long-term water management strategies, through site closure. In the event of a well

shut-in, the Facility will maintain permitted options for managing wastewater using a Reverse Osmosis system, transferring to another Mosaic facility, storing wastewater within the gypstack system, or other permitted treatment and disposal options, until the UIC can be resumed.

As shown in **Exhibit 3**, IW-1 is designed as a multi-stage cased well with a total depth (TD) of approximately 5,250 feet below land surface (bls). IW-1 will be constructed with five telescoped steel casings (diameters 60-inch, 50-inch, 40-inch, 30-inch, and 20-inch) installed to isolate individual groundwater production zones as the well is drilled to depth, as shown in **Exhibit 4**. All steel casings installed during construction of the well will be cemented to land surface with type II or 1L cement. The final casing depth is estimated to be 4,110 feet bls. The well is planned to be drilled to TD estimated at 5,250 feet bls and completed with an open hole injection zone in the Upper Cretaceous Permeable Zone (UCPZ) of the Cedar Keys Formation and the underlying Lawson Limestone. Mosaic will confer with FDEP about potential changes to the injection zone based on findings through exploratory drilling.

The base of the USDW (groundwater having a total dissolved solids concentration of less than 10,000 milligrams per liter [mg/L]) was identified approximately 6 miles to the southeast at a depth of 2,950 feet bls at the Tampa Electric Company (TECO) Polk Power Station Well IW-1 (MWH, 2013) as shown on **Exhibit 16B**. In addition, the USDW was identified at a depth of 2,794 feet bls approximately 6 miles north at the KC Industries Well IW-1 (FDEP, 2019) also shown on **Exhibit 16B**. Additionally, **Exhibit 16C** estimates the base of the USDW at the Facility at approximately 2,730 feet bls. Based on this information and hydrogeological data obtained from other nearby wells, it is anticipated that the base of the USDW may occur at approximately 2,800 feet bls. The 30-inch OD intermediate carbon steel casing and 20-inch OD final seamless steel casing for Well IW-1 is designed to extend below the base of the USDW and will be adjusted to accommodate geological findings as the well is constructed.

During well construction cementing activities, and subject to the Department's approval, Mosaic may use an American Society for Testing and Materials (ASTM) C595M-21PLC/Type 1L cement with up to 6% bentonite or higher, by weight. Type II or IL neat cement will be used to cement the 60-inch, 50-inch, and 40-inch OD carbon steel casings from their bases back up to ground surface. Type II or IL neat cement will be used to cement the 30-inch and 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing from their bases in the casing-to-formation intervals and below the USDW. Type II or IL cement with up to 6% bentonite by weight may be used to cement the casing-inside-casing intervals above the USDW to ground surface for the 30-inch and 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing.

Since Well IW-1 is designed to meet the construction requirements for an industrial injection well, Mosaic will install a packer assembly to isolate the nominal 10.72-inch ID RedBox 1250 FRP injection tubing within the 20-inch OD final seamless steel casing. The annulus between the 20-inch OD final seamless steel casing and the nominal 10.72-inch ID RedBox 1250 FRP injection tubing will be cemented back to ground surface.

Well IW-1 will be drilled as a UIC Class V Exploratory Well (Class V, Group 9) to evaluate the injection potential of the UCPZ of the Cedar Keys Formation and the underlying Lawson Limestone. Mosaic intends to apply for re-classification (UIC Class I) following drilling and well construction in order to continue with operational injection testing as part of the long term water management strategy.

Dual-Zone Monitor Well (DZMW-1) Design (In Anticipation of Future Class I Permit)

Following the successful re-classification of Well IW-1 from a Class V Exploratory Well Permit to a Class I Industrial Injection Well Construction and Testing Permit to allow for operational testing, a dual-zone monitoring well (DZMW-1) will be constructed for continuous monitoring of the hydraulic head within two isolated monitoring zones (Upper Monitoring Zone [UMZ] and Lower Monitoring Zone [LMZ]). The UMZ will be located above the base of the USDW and the LMZ will be located just above the principal confining strata and below the base of the USDW, based on local ambient water quality conditions. Well DZMW-1 will also be used for collection of groundwater samples for laboratory analysis during injection well operation. As shown on **Exhibit 3**, the UMZ is anticipated to be constructed to a depth approximately 2,000 feet to 2,100 feet bls and the LMZ from approximately 2,920 feet to 3,020 feet bls. The exact monitoring intervals will be confirmed during the construction of IW-1. Following interval testing during the drilling of Well DZMW-1, groundwater quality will be evaluated, and the results provided to FDEP for final monitoring interval selection and approval.

Well DZMW-1 will be designed with pumps and piping to facilitate purging and collection of groundwater samples produced from the monitoring zones for disposal in the injection well or to the pre-treatment pump station for disposal in the injection well. The final design will be contingent upon the results of IW-1 and DZMW-1 drilling and testing.

Permit-specified groundwater quality analyses and hydraulic head measurements (elevation in feet) will be conducted in both monitoring zones (upper and lower) of Well DZMW-1. Upon FDEP's approval to commence operational testing, the collected data will be electronically measured and recorded for submittal, including the monthly operating reports for Well DZMW-1.

Shallow Pad Monitoring Well Design (For Monitoring During Construction)

Four (4) shallow pad monitoring wells (PMWs) are proposed, which will surround Well IW-1, for Surficial Aquifer System (SAS) water level and water quality monitoring as shown in **Exhibit 2A and 2B**. The locations of these shallow PMWs will be submitted to FDEP for approval prior to their installation and initiation of installation activities. Construction details of the PMWs are detailed in **Exhibit 5**.

Proposed Instrumentation and Control (For Future Class I Permit)

A preliminary wellhead drawing for Wells IW-1 and DZMW-1 is provided in **Exhibit 6**. The preliminary process flow diagram that shows the interrelationship of the well, pumping station, and monitoring and control instrumentation will be provided with the UIC Class I Well Construction Permit Application submittal at a later date.

Proposed Monitoring for Operational Testing (For Future Class I Permit)

Following the construction and testing of Well IW-1, Mosaic expects to seek to re-classify the injection well system as a UIC Class I industrial injection well for operational testing. Once in service, a monitoring program will commence which will include the required operational data and water quality sampling per the Class I well construction permit.

The Facility wastewater will undergo pre-treatment, including to adjust the water chemistry for compatibility with the subsurface formations. As required for the Class I re-classification, an initial waste stream analysis of the treated process water will be collected for the following water quality parameters prior to operation:

- Primary Drinking Water Standards. Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only in the initial waste stream analysis;
- Secondary Drinking Water Standards; and Wastewater Quality Indicators

Injection Well Drilling Containment Pad

During drilling and testing, the exploratory injection well and dual-zone monitor well will be isolated within temporary fabricated-steel (or equal) fluid containment pads beneath the drilling rigs and substructures. Temporary fabricated-steel (or equal) secondary containment pads will be used beneath the mud tanks, pumps and fuel tanks. Mosaic will submit final designs of the fluid containment pads to FDEP for approval prior to the initiation of construction activities.

2. **Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.**

The proposed Injection Well System will be located in Polk County, Florida, as shown in **Exhibit 2.** Mosaic continues to evaluate potential locations at the Facility for the system siting. Preliminary primary location coordinates for both Wells IW-1 and DZMW-1 are shown below in **Table 2-1**. Preliminary secondary location coordinates for both Wells IW-1 and DZMW-1 are shown below in **Table 2-2. Exhibit 2** displays proposed primary and secondary well locations. The information presented in **Exhibit 7A** has been used to calculate the theoretical injection radius of influence to a radius of approximately 3,941 feet (0.75 miles) over a 10-year period (two permit durations). This calculation assumes a maximum continuous injection rate of 4.00 MGD. **Exhibit 7B** predicts the fluid migration radius over time. The modelling scenario considered a conservative injection zone thickness (200 feet) and effective porosity (0.20 dimensionless) based on current FDEP guidance.

Table 2-1 Proposed Primary Location for Wells IW-1 and DZMW-1

Well ID	Latitude	Longitude
Exploratory Well IW-1 (Proposed)	27° 47' 37.64" N	82° 2' 13.94" W
Dual-Zone Monitoring Well DZMW-1 (Proposed)	27° 47' 37.58" N	82° 2' 15.63" W

Table 2-2 Proposed Secondary Location for Wells IW-1 and DZMW-1

Well ID	Latitude	Longitude
Exploratory Well IW-1 (Proposed)	27° 47' 31.50" N	82° 2' 35.80" W
Dual-Zone Monitoring Well DZMW-1 (Proposed)	27° 47' 31.44" N	82° 1' 34.11" W

Exhibit 8 and **Exhibits 10A** through **10I** are aerial maps showing the potential well siting area, the Facility (with the AOR), major roads and surface water bodies. The proposed Well IW-1 site has a land surface elevation of approximately 160 to 161 feet above the North American Vertical Datum of 1988 (NAVD 88) (ArcGIS, 2020), as shown in **Exhibit 1**. The Facility is located in a rural area and is approximately 22 miles inland from seawater (i.e., Tampa Bay).

Over several decades, Mosaic has performed detailed investigations to locate all wells that extended through and below the SAS in the vicinity of the New Wales plant. As these wells were removed from service they were plugged and abandoned in accordance with State standards per Chapter 40D-3, Florida Statutes. For the purpose of this application, a comprehensive investigation including a review of multiple public databases was completed in February 2024. A total of 1,457 wells were identified within the AOR (which fully lies within the Mosaic property line) from the collection of well permits within the public domain databases from the United States Geological Survey (USGS), Florida Geological Survey (FGS) Bureau of Mining and Minerals, Florida Department of Environmental Protection (FDEP), South Florida Water Management District (SFWMD) and Southwest Florida Water Management District (SWFWMD), of which 1,428 wells are owned by Mosaic. These records were reviewed to assess the integrity of the confining units within the AOR. Many of the wells are represented in multiple databases, or even within the same database as both construction and abandonment permits for the same well. **Exhibit 9** provides a tabulation of wells found within the AOR; the wells are indexed and presented on the aerial maps shown in **Exhibits 10A** through **10I**. It should be noted that some of the wells in the inventory may be duplicated due to the nature of extracting data from numerous databases and therefore, **Exhibit 9** provides a total tabulation of wells from each database. Exhibits are outlined as follows:

- **Exhibits 9**: Tabulation of Wells Found within the AOR;
- **Exhibit 10A**: FGS Database Wells within the AOR;
- **Exhibit 10B**: USGS Database Wells within the AOR;
- **Exhibit 10C**: SFWMD and SWFWMD Database Wells within the AOR;
- **Exhibit 10D**: FDEP Database UIC Monitoring Wells within the AOR;
- **Exhibit 10E**: FDEP Database UIC Class V Non-ASR Wells within AOR;
- **Exhibit 10F**: FDEP Database UIC Class V ASR Wells within AOR;
- **Exhibit 10G**: FDEP Database UIC Class I Wells within the AOR;
- **Exhibit 10H**: FDEP Permitted Oil and Gas Database Wells within the AOR;
- **Exhibit 10I:** Mosaic Wells Inventory within the AOR;

There are no wells known to be improperly abandoned and none of the well construction permits identified within the AOR indicate penetration depths within an order of magnitude of the proposed injection or deep confining zones. The deepest well in the AOR belongs to Mosaic and was identified with the well ID of 038 with a total depth of 4,250 feet bls; according to the FDEP Class V Non-ASR database, the well has been properly plugged and abandoned. Therefore, no wells penetrate the depths of the proposed UMZ (2,000 feet to 2,100 feet bls), the LMZ (2,920 feet to 3,020 feet bls) or injection zone (beginning at approximately 4,110 feet bls). **Table 2-3** and **Table 2-4** summarize the wells in the AOR and are separated by agency database, well type, and maximum depth.

Table 2-3 Summary of Wells per Database Inside AOR

Agency	Monitor/ Test/ Stratigraphic / Dewatering	Water Supply (Domestic/Public/ Industrial/Fire/ Irrigation/Livestock/ Mining)	Remediation /Repair or Deepen/Sealing Water	Plugged & Abandoned	Oil and Gas Exploration (Stratigraphic Well)	Unknown	Total
FGS	2	-	-	-	1	-	3
USGS	20	-	-	-	-	-	20
SWFWMD / SFWMD	978	23	8	394	-	6	1,409
FDEP	-	25	-	-	-	-	25
Total	1,000	48	8	394	1	6	1,457

Table 2-4 below summarizes the maximum depths of the wells within the AOR. Plugged and abandoned wells and proposed wells are included in the summary.

Table 2-4 AOR, Summary of Wells Maximum Depth (feet bls)

Agency	Monitor /Test	Water Supply (Domestic/Public /Industrial)	Remediation (recovery)/Repair or Deepen	Plugged & Abandoned	Oil and Gas Exploration (Stratigraphic Well)	Unknown	Maximum Depth (feet bls)
FGS	814	-	-	-	736	-	814
USGS	948	-	-	-	-	-	948
SWFWMD/ SFWMD	950	814	500	1,068	-	520	1,068
FDEP	-	4,250	-	-	-	-	4,250
Maximum Depth	**950**	**4,250**	**500**	**1,068**	**736**	**520**	**4,250**

FGS Well Inventory

In the FGS database, shown in **Exhibit 10A**, 3 wells are documented within the AOR for this well survey. The three wells identified in the AOR were classified as:

- 2 Observation and Monitoring
- 1 Oil and Gas Exploration (**Exhibit 10H**). Based on communication with the Oil and Gas Department of the FGS on December 20, 2023, the Oil and Gas Exploration well identified with Borehole number 9.025, and well name "HORC - Intnl. Mineral & Chem. (F-137)" is not technically an oil and gas well but rather a stratigraphic well that was drilled in an effort to locate potential oil plays.

These wells vary in total depth from 315 feet to 814 feet. The deepest documented well is owned and operated by Mosaic and is located within the boundary of the Facility. Based on the location and depths of these wells, they are not expected to be affected by the operation of the proposed IW system.

USGS Well Inventory

In the USGS database, shown in **Exhibit 10B**, 20 wells are documented within the AOR for this well survey. The 20 wells identified in the AOR were classified as inactive groundwater monitoring wells.

The wells identified in the USGS inventory range from 15 feet to 948 feet bls with the deepest well located within the boundary of the Facility. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

SWFWMD/SFWMD Well Permit Inventory

A total of 1,409 wells were identified within the AOR in the SWFWMD/SFWMD wells inventory, shown in **Exhibit 10C**, of which there are 4 wells highlighted in red and shown in **Exhibit 9**, that are not denominated as being on Mosaic's property and are therefore mislocated in the SWFWMD database. Excluding these wells, the 1,409 wells identified in the AOR were classified as follows:

- 1 Aquifer Performance Test
- 468 Dewatering
  - 15 of these are Proposed Well Construction Permits (WCP) Wells
- 7 Domestic
- 2 Essential Services (Fire Protection)
- 5 Industrial
  - 1 of these is Proposed WCP Well
- 2 Irrigation
- 5 Mining
- 313 Monitor
  - 213 of these are Proposed WCP Wells
- 394 Plugged
  - 335 of these are Proposed WCP Wells
- 2 Public Supply
- 1 Repair or Deepen (use not specified)
- 7 Sealing water
- 196 Test
  - 181 of these are Proposed WCP Wells
- 6 Unknown

The wells identified range from 6 feet to 1,068 feet bls with the deepest well located within the boundary of the Facility. The deepest documented well is owned and operated by Mosaic. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

FDEP Well Inventory

A total of 25 wells were identified within the 1-mile AOR in the FDEP well inventory:

- 0 Monitoring well (**Exhibit 10D**)
- 25 Class V non-aquifer storage and recovery (ASR) wells (**Exhibit 10E**)
- 0 Class V ASR well (**Exhibit 10F**)
- 0 Class I Industrial Injection well (**Exhibit 10G**)
- 0 Oil and Gas permitted well

The wells identified in the FDEP inventory range from 201 feet to 4,250 feet bls with the deepest well located at the west side within the boundary of the Facility. It is important to note that all of the 25 wells identified in the Class V non-ASR wells database are documented as being properly plugged and abandoned. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

Mosaic Inventory

A total of 1,428 Mosaic-owned wells were identified within the AOR and within the Facility property based on information obtained from various agency databases. These wells are shown within the well inventories of the USGS (13 wells), SWFWMD/SFWMD (1,387 wells), FGS (3 wells), and FDEP (25 wells) and are shown in **Exhibit 10I**. The owner of these wells, Mosaic, is identified in the well inventories under various names such as Mosaic Fertilizer and IMC – New Wales Operation, among others.

Table 2-5 below summarizes the Mosaic wells within the AOR databases. Plugged & abandoned wells and proposed wells are included in the summary.

Table 2-5 Summary of Mosaic Wells per Database Inside AOR

Agency	Monitor/ Test/ Stratigraphic /Dewatering	Water Supply (Domestic/Public/ Industrial/Fire/ Irrigation/Livestock/ Mining)	Remediation /Repair or Deepen/Sealing Water	Plugged & Abandoned	Oil and Gas Exploration	Unknown	Total
FGS	2	-	-	-	1	-	3
USGS	13	-	-	-	-	-	13
SWFWMD /SFWMD	975	17	8	381	-	6	1,387
FDEP	-	25	-	-	-	-	25
Total	**990**	**42**	**8**	**381**	**1**	**6**	**1,428**

3. Proposed other uses of the exploratory well.

Well IW-1 is expected ultimately be completed to meet the (F.A.C.) Rule 62-528 Class I Industrial injection well design, operation, and monitoring criteria. Following completion of IW-1 construction and testing, Mosaic expects to seek approval to convert to a Class I Industrial injection well, and will provide, as appropriate, any additional technical data, revised plugging and abandonment cost estimates, and financial assurance to support the change. The purpose of Well IW-1 is to obtain site specific geology, water quality and confinement characteristics to determine the ideal interval for the injection of pre-treated, non-hazardous process water.

4. Drilling and testing plan for the exploratory well. The drilling plan must identify the proposed drilling program, sampling, coring, and testing procedures.

The following section provides an overview of the construction program for the Well IW-1, and associated PMWs. The drilling and testing program for the Well IW-1, and associated PMWs will include information on cementing and casing programs, geophysical logging schedule, lithologic sampling, coring, packer testing, injection testing, and other hydrogeologic data collection procedures. These activities are detailed in **Exhibit 11A**. Pilot holes throughout the construction sequence shown below will be used to verify and validate the application information obtained from maps and cross-sections detailing the local area's hydrology and geologic structures. Information from the pilot holes will be then used to adjust casing set depths and design the well accordingly.

As shown in **Exhibit 11A** and **11B**, during all pilot holes for the construction of Wells IW-1 and DZMW-1, lithologic samples will be collected every 10 feet. Additionally, mechanical deviation surveys will be collected at 90-foot intervals. Once construction switches from direct mud rotary drilling to reverse air drilling method, reverse air water quality samples will be collected at 45-foot intervals. Geophysical logging will be completed at the completion of every pilot hole and reamed hole. For hydrogeological testing and analysis above and below the base of the USDW, a 12.25-inch diameter pilot-hole will be drilled in multiple stages and tested to an estimated depth of approximately 5,250 feet bls. Core sampling and packer testing at Wells IW-1 and DZMW-1 will be conducted to evaluate the subsurface hydrogeology. This information will provide data to properly design Well IW-1 regarding the final casing seat depths and total borehole depth along with the associated Well DZMW-1 monitoring zones.

A steel (or equivalent as approved by the FDEP) fluid containment pad beneath the drill rig and rig substructure with secondary containment beneath mud tanks, mud pumps and fuel tanks will be built prior to commencing drilling at the Well IW-1 location to contain drilling fluids and to prevent water quality impacts to the SAS. Additionally, a National Environmental Laboratory Accreditation Program (NELAP) certified laboratory will be available to sample and analyze (in accordance with FDEP Standard Operating Procedures [SOPs]) the PMWs throughout construction and testing to confirm no water quality impacts to the SAS.

The proposed work sequence for the mobilization and site preparation will be as follows:

1. Install temporary water, sewer, electrical, wireless internet, and cell phone services.
2. Conduct a pre-construction video survey of the site to document existing site conditions.
3. Perform site preparation: clearing, grubbing, stripping and debris removal. Remove and dispose of non-hazardous debris and build up soil sub-base for drilling pad.

4. Drill a pilot hole to confirm the base of the surficial aquifer. The casing seat depth of the 60-inch OD (wall thickness to be determined) pit carbon steel casing will terminate in the confining unit (Intermediate Confining Unit) for isolation of the Surficial Aquifer and stabilize shallow unconsolidated sediments for drilling operations. The casing seat depth will be determined by the Contractor and reviewed and approved by the Project Geologist/Engineer prior to its installation. Excavate fill materials and install a 60-inch OD (wall thickness to be determined) pit carbon steel casing to the depth required for the drilling system; the Project Geologist/Engineer will oversee the installation of the pit casing. The final floor elevation within the pit casing will accommodate the installation of a rotating head or other sealing mechanisms to control fluids during drilling. Excavated materials shall be stockpiled onsite.

5. Construct a temporary fabricated steel (or equal) fluid containment pad.

6. Install, develop, and sample four 4-inch diameter polyvinyl chloride (PVC) shallow PMWs at approved locations, as required by the FDEP. PMW locations are shown in **Exhibit 2** and PMW construction details are show in **Exhibit 5**. NELAP certified laboratory will be utilized to conduct analyses on background samples collected at the PMWs.

7. Mobilize drilling and other required materials and equipment required for construction.

The sequential description of construction, well drilling and testing activities associated with IW-1 is shown below. **Exhibit 11A** provides a summary of testing to be conducted while drilling Exploratory Well IW-1.

1. Drill a pilot hole with a 12.25-inch diameter bit to approximately 550 feet bls using the direct mud-rotary method. Record mechanical deviation surveys and collect rock formation samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

2. Conduct geophysical logging [Caliper (CAL), natural gamma-ray (NGR), spontaneous potential (SP), dual-induction (DIL), borehole compensated sonic w/ variable density log (BHCS/VDL) and Acoustic Borehole Imager (ABI)] in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

3. Ream the pilot hole to a nominal 60-inch diameter borehole to approximately 515 feet bls using the direct mud-rotary method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

4. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

5. Install the 50-inch OD surface carbon steel casing to approximately 510 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**, and cement to surface. Conduct geophysical logging [Temperature (TEMP) and NGR] after each cement stage in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1** to confirm top of cement in conjunction with measurement from tremie pipe hard tags.

6. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

7. Drill out cement plug and drill a pilot hole centered at the bottom of the 50-inch OD surface carbon steel casing with a 12.25-inch diameter bit to approximately 1,400 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

8. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, color video survey (TV) or Optical Borehole Imager (OBI) or ABI, TEMP, fluid resistivity (FR) and flowmeter (FM); Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

9. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

10. Back-plug the pilot hole with cement to the base of the 50-inch OD surface carbon steel casing.

11. Ream the pilot hole to a nominal 50-inch diameter borehole to approximately 1,355 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

12. Conduct geophysical logging (CAL and NGR) in the reamed hole in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

13. Install the 40-inch OD intermediate carbon steel casing to approximately 1,350 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

14. Drill out cement plug and drill a pilot hole centered at the bottom of the 40-inch OD intermediate carbon steel casing with a 12.25-inch bit to approximately 3,100 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

15. During drilling of the pilot hole collect up to four (4) cores at depths selected in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

16. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

17. Conduct up to four (4) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

18. Back-plug the pilot hole with cement to the base of the 40-inch OD intermediate carbon steel casing.

19. Ream the pilot hole to a nominal 40-inch diameter borehole to approximately 3,005 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

20. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

21. Install the 30-inch OD intermediate carbon steel casing to approximately 3,000 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

22. Drill out cement plug and drill a pilot hole centered at the bottom of the 30-inch OD intermediate carbon steel casing with a 12.25-inch bit to 5,250 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation, and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

23. During drilling of the pilot hole collect up to eight (8) cores at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

24. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

25. Conduct up to four (4) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

26. Install drillable bridge plug at a depth of ±4,130 feet bls.

27. Back-plug the pilot hole with cement to the base of the 30-inch OD intermediate carbon steel casing.

28. Ream the pilot hole to a nominal 30-inch diameter borehole to approximately 4,115 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

29. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

30. Install the 20-inch OD final seamless steel casing to approximately 4,110 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1.**

31. Cement the 20-inch OD final seamless steel casing from the bottom of the casing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**. Logging may be waived if poor fill-up is encountered.

32. Conduct a standard cement bond log following completion of cementing of the 20-inch OD final seamless steel casing to within 300 feet of land surface in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

33. Cement the final ±300 feet of the 20-inch OD final seamless steel casing.

34. Conduct casing pressure test of the 20-inch OD final seamless steel casing in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

35. Drill out cement plug at the base the 20-inch OD final seamless steel casing and ream the pilot hole to a nominal 20-inch diameter borehole to approximately 5,250 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**.

36. Conduct geophysical logging (CAL, NGR, TV) in accordance to **Exhibit 18A - Summary of Testing for Exploratory Well IW-1**.

37. Install the 10.72-inch ID Red Box 1250 FRP tubing (or approved equal) and cementing packer to approximately 4,100 feet bls with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1**.

38. Cement the 10.72-inch ID Red Box 1250 FRP injection tubing from the bottom of the tubing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**. Logging may be waived if poor fill-up is encountered.

39. Conduct a standard cement bond log following completion of cementing of the 10.72-inch ID Red Box 1250 FRP injection tubing to within 300 feet of land surface in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

40. Cement the final ±300 feet of the 10.72-inch ID Red Box 1250 FRP injection tubing.

41. Conduct casing pressure test the 10.72-inch ID Red Box 1250 FRP injection tubing in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

42. Develop the well (injection zone). Dispose of produced settled water in the discharge location at the Facility approved by the engineer of record (EOR). Purge well in accordance with FDEP SOP protocol.

43. In accordance with FDEP SOP protocol, upon completion of development, collect background groundwater samples from the injection zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only for the background groundwater samples) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

44. Complete installation of wellhead fittings and valves in accordance with **Exhibit 6 – Exploratory Well IW-1 and Dual-Zone Monitor Well Wellhead Completion Details**.

45. Prepare for remaining mechanical integrity testing and furnish and install temporary piping, pumps, and valves to deliver clean and clear water for conducting a color video survey for the

final inspection of the 10.72-inch ID Red Box 1250 FRP injection tubing and open hole in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

46. An injection test shall be conducted upon re-classifying the well for operation as a Class I Industrial Injection Well. Once re-classified, FDEP will be notified of injection testing and conducting external mechanical integrity testing with geophysical logging (NGR, high-resolution temperature [HRT] log and a radioactive tracer survey [RTS]) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

47. Install temporary barriers and final concrete pad. Plug and abandon temporary shallow monitoring wells.

48. Clean and restore disturbed areas around the drilling site.

The following provides a description of the construction, well drilling, and testing activities associated with the construction of DZMW-1, which will be permitted through the future Class I Construction Permit Application. **Exhibit 11B** provides a Summary of Testing to be conducted during construction activities. The final design of DZMW-1 will be contingent upon the results of IW-1 drilling and testing.

1. Drill a pilot hole to confirm the base of the surficial aquifer. The casing seat depth of the 34-inch OD (wall thickness to be determined) pit carbon steel casing will terminate in the confining unit (Intermediate Confining Unit) for isolation of the Surficial Aquifer and stabilize shallow unconsolidated sediments for drilling operations. The casing seat depth will be determined by the Contractor and reviewed and approved by the Project Geologist/Engineer prior to its installation. Excavate fill materials and install a 34-inch OD (wall thickness to be determined) pit carbon steel casing to the depth required for the drilling system; the Project Geologist/Engineer will oversee the installation of the pit casing. The final floor elevation within the pit casing will accommodate the installation of a rotating head or other sealing mechanisms to control fluids during drilling. Excavated materials shall be stockpiled onsite.

2. Construct a temporary fabricated steel (or equal) fluid containment pad.

3. Install four (4) 4-inch diameter PVC shallow PMWs at locations approved by the FDEP. PMW locations are shown in **Exhibit 2 Proposed Exploratory Well, Dual-Zone Monitoring Well and Pad Monitoring Well Locations** and PMW construction details are show in **Exhibit 5 – Pad Monitoring Well Design**. A NELAP certified laboratory will be utilized to conduct analyses on background samples collected at the PMWs.

4. Mobilize and set up drilling equipment at the MW site.

5. Drill a nominal 12.25-inch diameter pilot hole using standard mud-rotary drilling methods to approximately 550 feet bls, record mechanical deviation surveys and collect rock formation samples at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

6. Conduct geophysical logging in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** (CAL, NGR, SP, DIL, BHCS w/ VDL and ABI).

7. Ream pilot hole to nominal 34-inch diameter borehole using the direct mud-rotary method to approximately 515 feet bls and record mechanical deviation surveys at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

8. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

9. Install the 24-inch OD surface carbon steel casing (0.500-inch wall) to approximately 510 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**, and cement to surface. Conduct geophysical logging [Temperature (TEMP) and NGR] after each cement stage in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm top of cement in conjunction with measurement from tremie pipe hard tags.

10. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

11. Drill out cement plug and drill a nominal 12.25-inch diameter hole centered at the bottom of the 24-inch OD casing to approximately 2,100 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock/water formation samples, and analyze air-lifted water samples during reverse-air drilling in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

12. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

13. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Collect and analyze (NELAP-Certified laboratory) groundwater samples during packer testing to confirm the water quality of the UMZ.

14. Install drillable bridge plug at a depth of ±2,015 feet bls.

15. Back-plug the pilot hole with cement to the base of the 24-inch OD surface carbon steel casing.

16. Ream pilot hole to nominal 24-inch diameter borehole using the direct mud-rotary method to approximately 2,005 feet bls and record mechanical deviation surveys at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

17. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

18. Install the 16-inch OD final seamless steel casing to approximately 2,000 feet bls in accordance with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

19. Drill out cement plug and drill a nominal 12.25-inch diameter hole centered at the bottom of the 16-inch OD final seamless steel casing to approximately 3,020 feet bls using the reverse-air

circulation method. Record mechanical deviation surveys, collect rock/water formation samples, and analyze air-lifted water samples during reverse-air drilling in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

20. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

21. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Collect and analyze (NELAP-Certified laboratory) groundwater samples during packer testing to confirm the water quality of the LMZ.

22. Install the 6.21-inch ID Red Box 1250 FRP tubing (or approved equal) with attached external cementing packer to approximately 2,920 feet bls in accordance with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**. and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

23. Cement approximately 820 feet of the bottom 6.21-inch ID Red Box 1250 FRP tubing, from approximately 2,920 feet to 2,100 feet bls. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

24. Conduct CBL once cementing is complete in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**

25. Install temporary wellhead appurtenances, and after the cement has cured, perform casing pressure test on the 6.21-inch ID FRP tubing using an inflatable down-hole packer in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**

26. Develop both monitoring zones in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**, following FDEP SOP protocol. Upon completion of development, collect a groundwater sample from each completed monitoring zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only for the background groundwater samples) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

27. Perform final inspection of 6.21-inch ID FRP tubing by running a CAL log (open-hole only) and TV survey while flowing or pumping the 6.21-inch ID FRP tubing in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Discharge produced settled water to discharge location at the Facility approved by the EOR.

28. Install temporary wellhead assembly and appurtenances in accordance with **Exhibit 5 – Temporary Wellhead Drawings**.

29. Install temporary pressure transducer in each monitoring zone (UMZ and LMZ) for measurement of artesian head (elevation) during pre-injection test background period, injection testing, and recovery periods (pending FDEP approval).

5. Abandonment plan.

This Plugging and Abandonment (P&A) plan outlines the procedures and estimated cost for P&A for Well IW-1, which is expected to be converted into Injection Well IW-1, and for the Dual-Zone Monitor Well DZMW-1 located at the Facility. Well IW-1 will have an approximate depth of 5,250 feet bls, while Well DZMW-1 will have an approximate depth of 3,020 feet bls. If the injection well system is abandoned, the injection zone and monitoring zones must be effectively plugged and sealed to prevent the upward migration of fluid from the injection zone and/or an interchange of formation water between aquifers. The P&A opinion of estimated costs is provided in **Exhibit 12A,** and the Abandonment Details are provided in **Exhibit 12B**.

This P&A plan describes a procedure for plugging and sealing Well IW-1 and both monitoring zones of Well DZMW-1 using gravel and cement. Gravel will be used to fill in the injection zone up to 10 feet below the base of the FRP tubing. The 10.72-inch ID FRP injection tubing will then be plugged with cement from above the gravel top to land surface. For Well DZMW-1, each monitoring zone will be filled with gravel in the open borehole intervals and each respective casing will be cemented to land surface.

The following is a sequence of gravel and cement sealing of the Well IW-1 injection zone and of the Well DZMW-1 monitoring zones. The cost calculations allow for the purchase of all the materials and services necessary for well abandonment tasks and represent the approximate cost for P&A of the Wells IW-1 and DZMW-1, including a 10% contingency and estimated associated oversight for engineering costs of 20%.

As presented in **Exhibit 12B**, the materials, quantities and services provided to plug Well IW-1 will proceed as follows:

1. Mobilize drill rig, kill the well by filling the cemented 10.72-inch ID FRP injection tubing with weighted drilling mud or salt, and remove the valve assembly and appurtenances from the wellhead. Conduct geophysical logging.

2. Add a volume of crushed limestone gravel to the well equal to the volume of the open hole section of Well IW-1 to fill the open formation to approximately 10 feet below the bottom of the 10.72-inch ID FRP injection tubing. Verify the depth to the top of the gravel by tagging with a wireline. Place neat cement in stages into the 10.72-inch ID FRP injection tubing through a tremie pipe to the top of the gravel. The quantity of cement pumped above the top of the gravel should be equivalent to the volume of cement required to fill approximately 10 feet of open hole and the entire length of 10.72-inch ID FRP injection tubing.

3. The cement should be allowed to set for 12 to 24 hours and then hard tagged with a wireline or tremie pipe to determine if sufficient fill up has been achieved.

4. The remainder of the 10.72-inch ID FRP injection tubing can then be filled with neat cement using the tremie method to land surface.

The UMZ and LMZ of Well DZMW-1 will be plugged by filling the open-hole portion of each zone with gravel up to 10 feet below the base of the respective casing and pumping cement to fill each respective casing to land surface in stages. The LMZ will be abandoned first followed by the UMZ. As presented in **Exhibit 12B**, the proposed plan to abandon Well DZMW lower and upper zones by gravel and cement method will proceed as follows:

1. Mobilize a drill rig and kill the well by partially filling the 6.21-inch ID FRP tubing of the LMZ with weighted drilling mud or salt. Remove the wellhead flanges and appurtenances from the well. Conduct geophysical logging.

2. Add a volume of gravel to the well equal to the volume of the open-hole sections of the monitoring zones. Fill the open-hole with gravel to approximately 10 feet below the bottom of each casing (to 2,930 feet bls within the LMZ and to 2,010 feet bls within the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD final seamless steel casing). Verify the depth to gravel placement by hard tagging the gravel top in both zones with a wireline or tremie pipe.

3. For the LMZ, pump neat cement on top of the gravel placed in the 6.21-inch ID FRP tubing. For the UMZ, pump neat cement on top of the gravel through a tremie pipe placed in the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD final seamless steel casing. Fill the casings with the neat cement in stages to land surface.

4. Verify the depth of each stage by hard tagging the cement top with a wire line or tremie pipe.

5. Complete below ground and add monument.

3.0 Supplemental Information - Future Class I Industrial Injection Well Permit Application

(Responses to Part A, Numbers 1-5 of Form 62-528.900(1))

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. **A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.**

This information was provided in Item No. 2 Part (F) of Form 62-528.900(1). Also, please see **Exhibits 7A, 7B, 9, and 10A-10H** for associated AOR information.

2. **A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.**

This information was provided in Item No. 2 Part (F) of Form 62-528.900(1). Also, please see **Exhibit 9** tabulation of wells found within the 1-Mile Area of Review.

3. **Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.**

The different terminology for the hydrogeologic units of the Floridan Aquifer System (FAS) over different studies is presented in **Exhibit 13** (Williams and Kuniansky, 2016). A stratigraphic column showing the relation of hydrogeologic units of the FAS to geologic units and their lithology based on the hydrogeologic framework report *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida* is presented in **Exhibit 14A** (Reese, R. S. and Richardson E., 2008). **Exhibit 14B** provides a regional stratigraphic column of the Paleogene through the Upper Jurassic aged geologic formations of the South Florida Basin (Roberts-Ashby et al., 2013).

Near the Facility, underground sources of drinking water are present in the upper FAS and potentially in the lower FAS. A potentiometric map of the UFA of the FAS which shows groundwater flow is toward the coast (West) is presented in **Exhibit 15A**. The elevation of the top of the FAS is highly variable onsite and ranges from approximately -100 feet NGVD29 as depicted on **Exhibit 15B.** The elevation of the top of the LFA is at approximately -1,600 feet NGVD29 as shown in **Exhibit 15D.** **Exhibit 15E** shows the elevation of the base of the FAS, which is approximately -3,300 feet NGVD29. A map of water quality zone contours

indicating the elevation of the 10,000-mg/L TDS isopleth (USDW) throughout Florida is presented in **Exhibit 15F**, indicating its presence at approximately 2,400 feet NGVD29 below the Facility. This map also shows that the Facility is in a potential salinity inversion area, meaning fresher water could lie beneath more saline water, which could indicate that the true base of the USDW is deeper than this depth. The estimate of the base of the USDW from **Exhibit 15F** is approximately 400 feet shallower than the anticipated base of the USDW discussed in Section 2, Item No. 1. Based on the local and regional hydrostratigraphic cross sections utilizing nearby wells presented in Exhibits **16B**, **16C**, **17B**, **17C**, and **17D**, the base of the USDW is anticipated to be at 2,800 feet bls below the Facility. An isopach map displaying the thickness of freshwater in the FAS is shown in **Exhibit 15G**, which shows the Facility lies above freshwater saturated zone that is approximately 2,200 feet thick.

An elevation map of the Oldsmar Formation Permeable Zone including the geographical extent of the higher-permeability unit called the Boulder Zone is presented in **Exhibit 15H**. This figure shows the Boulder Zone is not present and that the estimated TDS concentration to be less than 10,000 mg/L in the region of northwest Polk County, meaning, a USDW could be present in the Oldsmar Formation Permeable Zone below the Facility. The thickness of the Middle Cedar Keys Formation which serves as a confining unit (Sub-Floridan Confining Unit [SFCU]) below the LFA is presented in **Exhibit 15I**. A map displaying the thickness of the Lower Cedar Keys and Upper Lawson Limestone Formations, a portion of the proposed injection zone (UCPZ), is provided in **Exhibit 15J**. These two maps were obtained from a regional investigation of using the Lower Cedar Keys and Upper Lawson Limestone Formations as an injection zone for carbon sequestration (Roberts-Ashby et al., 2013).

The potentiometric surface of deeper hydraulically isolated zones below the FAS, particularly the Upper Cretaceous Permeable Zone, have not been extensively mapped like the UFA. The potentiometric surface of the Upper Cretaceous Permeable Zone may be influenced by the operation of existing IWs used to dispose of municipal or industrial effluent, such as those at the Tampa Electric Company (TECO) Polk Power Plant approximately 6 miles southeast of the Facility. Since no operational injection wells have been constructed or operated within the AOR for this project, the presence of effluent/concentrate in the proposed injection zone or confining units is not expected at the Facility.

Local hydrostratigraphic cross sections A-A’ and B-B’ are presented in **Exhibits 16B and 16C**. The depths of nearby USDWs (defined by the 10,000 mg/L-isopleth) were gathered from construction and testing reports of nearby wells and are indicated in **Exhibits 16B and 16C.** Using this information, the anticipated depth of the USDW at the Facility is expected to be approximately 2,800 feet bls. Regional cross sections J-J’, O-O’ and P-P’ published in a revised hydrogeologic framework of the FAS report prepared by the USGS are presented in **Exhibits 17B, 17C, and 17D**, respectively (Williams and Kuniansky, 2016). The depths of USDWs in the nearby wells used for the study are included in these figures.

The base of the USDW is expected to be approximately 835 feet below the base of the Middle Confining Unit II (MCU II) and is expected to lie approximately 165 feet above the top of the SFCU. The MCU II is expected to be approximately 660 feet thick and the SFCU is expected to be approximately 1,058 feet thick below the Facility. The top of the injection zone, the UCPZ, is expected to be encountered approximately 1,223 feet below the base of the USDW. These estimated depths and thicknesses are based on the hydrogeological investigation performed during the creation of local hydrostratigraphic cross sections, discussed further in Item No. 4 below.

While we anticipate likely drilling the open hole to 5,000 ft bls, so that the injection zone would be located in the UCPZ of the Cedar Keys Formation and the underlying Lawson Limestone, should testing results indicate that the strata above 4,110 ft bls and below the base of the USDW are sufficiently transmissive to accept the target injected water flow, and that there is sufficient confinement between the USDW and the proposed injection zone, then Mosaic will confer with FDEP about potential changes to the injection zone.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

Review of published literature revealed no confirmed geologic, tectonic, or physiographic structures, such as faults or folds, at the Facility.

A geological structure map of Florida is presented in **Exhibit 18**. As shown in this exhibit, the Tampa Sarasota Arch is located very close to the Facility. Regional information on the geologic setting is presented below in Item No. 5.

One north-south trending local cross section, A-A’, and one east-west trending cross section, B-B’, are presented in **Exhibits 16B and 16C**. A location map for these hydrostratigraphic cross-sections utilizing available data from deep wells within Hillsborough, Pinellas, Polk, Pasco, Sumter, and Hardee Counties, is presented in **Exhibit 16A**. These cross-sections were developed using available data from the FDEP Geospatial Open Data Portal, the FDEP Oculus Electronic Management System, and the South Florida Water Management District’s (SFWMD) DBHydro environmental database. Delineation of the hydrostratigraphic boundaries were established primarily from the construction and testing reports of nearby wells as well as interpretation of geophysical logs and lithologic data. The depths of USDWs in these nearby wells are also included in these figures. The position of the proposed Facility IW System site is shown for reference on the cross-sections which show the general structure of the geologic units extending from land surface through the lower Eocene formations. Hydrostratigraphic boundaries for the following units are depicted:

- Surficial Aquifer System (SAS)
- Intermediate Confining Unit (ICU)
- Upper Floridan Aquifer (UFA)
- Middle Semi-Confining Unit I (MCU I)
- Avon Park Permeable Zone (APPZ)
- Middle Semi-Confining Unit II (MCU II)
- Lower Floridan Aquifer (LFA)
- Sub-Floridan Confining Unit (SFCU)
- Upper Cretaceous Permeable Zone (UCPZ)
- Semi-Confinement
- Lower Cretaceous Permeable Zone (LCPZ)

The uppermost aquifer system is the SAS and is composed of unconsolidated sands, clay, marl, shells, limestone, and sandy clay. In some areas of Central-West Florida, the SAS is not present because the FAS is exposed at the surface due to karst topographic features (Crandall, 2007). In Polk County, the SAS has a thickness of approximately 70 feet. The SAS is underlain by low-permeability sediments of the Hawthorn

Group from the Miocene Epoch. The Hawthorn Group contains sands, clays, limestones and varying amounts of phosphate and dolomite content. The Hawthorn group serves as a confining bed referred to as the ICU and these sediments are approximately 180 feet thick at the proposed Exploratory Well IW-1 location.

The top of the UFA of the FAS is encountered at the base of the ICU which coincides with either the limestones of the lower Arcadia Formation or the upper Suwannee Limestone at a depth of approximately 250 feet bls at the proposed Exploratory Well IW-1 location. A structure map showing the elevation of the top of the UFA throughout Florida is presented in **Exhibit 15B**. Researchers (Miller 1986; Reese, 1994) have described multiple discrete confining units separating the individual aquifers of the FAS. The Ocala Limestone and upper portion of the Avon Park Formation are typically composed of semi-low-permeability limestones and dolostones and serve as a semi-confining unit referred to as the MCU I (sometimes called the Ocala-Avon Park Lower Permeability Zone or OCAPLPZ) that separates the UFA from the APPZ. The extent of the MCU I is believed to “pinch out” or be very thin in much of Central-West Florida and therefore this unit, if present, is considered leaky at the Facility (Williams and Kuniansky, 2016). The presence of this zone will be confirmed during drilling of the exploratory well. The APPZ is a higher permeable zone of the Avon Park Formation and is sometimes considered part of the UFA (Reese and Richardson, 2008) or part of the LFA. Some researchers even refer to it as the “Middle Floridan Aquifer,” but is considered part of the UFA in this permit application. The entire UFA including the MCU I and APPZ is approximately 1,055 feet thick at the Facility.

Below the UFA is an evaporite-bearing confining unit generally considered not leaky in Central-West Florida, called the MCU II (Miller, 1986). The MCU II is sometimes referred to as the Middle Avon Park Composite Unit (Williams and Kuniansky, 2016) and contains lower permeability deposits such as gypsiferous dolostone, gypsum, anhydrite, limestone, and organic-rich clays in the middle and lower portions of the Avon Park Formation. The MCU II separates the UFA from the LFA. Beneath the Facility, the MCU II is expected to be approximately 660 feet thick, though could be interbedded with small permeable zones. **Exhibit 15C** presents a structure map showing the elevation to the top of the MCUI I and its general composition across Florida. **Exhibit 15D** presents a structure map showing the elevation to the top of the LFA. The LFA is comprised of the Lower Avon Park Formation, the Oldsmar Formation, and the Upper Cedar Keys Formation and contains all permeable zones below the MCU II, including a Lower Avon Park Permeable Zone and the Oldsmar Formation Permeable Zone (Williams and Kuniansky, 2016). The elevation of the top of the Oldsmar Formation Permeable Zone is presented in **Exhibit 15H,** which shows the water quality of this unit below the Facility could represent a USDW (TDS concentrations below 10,000 mg/L). This figure also shows that the higher permeable zone (Boulder Zone) of the Oldsmar Permeable Zone that other’s use as an injection zone for Class I Injection Wells in South Florida is not present below the site. The LFA is expected to be approximately 1,000 feet thick under the Facility.

The Cedar Keys Formation in West-Central Florida is typically classified into three units (upper, middle, and lower). The upper unit is typically considered part of the LFA. The middle unit is anhydrite-rich, low in permeability and typically considered the primary confining unit (serving as the SFCU in this case) in between the FAS and the UCPZ. The Lower Cedar Keys Formation and the Lawson Limestone are permeable and serve as the UCPZ. The UCPZ has been researched for its storage potential as an injection zone for injection wells, both Class I and Class VI Carbon Sequestration Wells (Roberts-Ashby et al., 2013). A map displaying the thickness of the Middle Cedar Keys Formation (that serves as the SFCU) is presented in **Exhibit 15I**. The SFCU is expected to be approximately 1,060 feet thick below the Facility based on the hydrostratigraphic projections from nearby wells and interpreted while creating the local cross sections provided in **Exhibits 16B** and **16C**. The upper member of the Lawson Limestone is mostly an algal and

rudistid biostrome that has undergone extensive alteration of the primary and is somewhat high in permeability (Applin and Applin 1944, 1965; Miller 1986; Roberts-Ashby et al., 2013) and the lower member is composed of chalk with thin lenses of dolostone and is lower in permeability (Roberts-Ashby et al., 2013). A map displaying the thickness of the Lower Cedar Keys Formation and the Upper Lawson Limestone (referred to as the Cedar Keys/Lawson Limestone injection zone [CKLIZ] in the figure) is presented in **Exhibit 15J**. These two formations have also been considered as a potential injection zone for carbon capture and sequestration (CCS), based on research by Roberts-Ashby et al., 2013, and do not include the Lower Lawson Limestone unit. This storage complex is depicted on the stratigraphic column provided in **Exhibit 14B**. The Lower Lawson Limestone is believed to be permeable enough to receive wastewater and is thus included in the LCPZ in the region of West-Central Florida according to the TECO IW-2 Well Completion Report (MWH, 2013b). The UCPZ is expected to be approximately 1,020 feet thick below the Facility.

5. Generalized maps and cross sections illustrating the regional geologic setting.

Three regional cross sections created during a regional USGS study *Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina* (Williams and Kuniansky, 2016) are presented in **Exhibits 17B, 17C, and 17D**. These include one north-south trending (J-J') and two east-west trending (O-O' and P-P'), respectively, in the region of the Facility. A location map for the wells used in these hydrostratigraphic cross sections is presented in **Exhibit 17A**. The depths of USDWs in nearby wells are also included in this figure. Hydrostratigraphic and lithologic boundaries are presented in these cross sections. All the regional-scale maps referred to in the above Item No. 4 are also relevant to Item No. 5.

The Facility is located within the Atlantic Coastal Plain physiographic region. The region's geologic and tectonic setting is the product of a complex history of continental collisions and rifting followed by deposition of sediments on the Florida platform. Basement rocks consist of Paleozoic and Mesozoic aged igneous, metamorphic, and sedimentary rocks. The overlying Mesozoic Era carbonate and evaporite sedimentary rocks may be 15,000 feet thick (Miller, 1986). Overlying the Mesozoic Era rocks is approximately 6,000 feet of Cenozoic Era carbonate and siliciclastic sedimentary rocks (Applin and Applin, 1944, Arthur, J.D., 1988; Milton, C., 1972). The geologic structures as shown in **Exhibit 18** that have affected shallow Tertiary and Quaternary Period sediments of the Florida Platform have been defined by numerous authors (Puri and Vernon, 1974; Miller, 1986; Scott, 1988; Scott, 1992). Most of the structures recognized as influencing the deposition, erosion and alteration of the Cenozoic Era sediments in Florida do not appear to have had a significant effect on the surface expression of the lithostratigraphic units (Scott, 1988).

Previously mentioned, local hydrogeologic cross-sections for west-central Florida are shown in **Exhibits 16B and 16C. Exhibit 14B** provides a generalized stratigraphic column of the geologic formations below the region of the Facility obtained from a regional-scale investigation of using the Upper Cretaceous units in Florida as an injection zone for carbon sequestration (Roberts-Ashby et al., 2013). A geologic map of the Northern Florida Peninsula is presented in **Exhibit 18A and 18B**. The position of the proposed Facility IW System site is shown for reference on the cross-sections which show the general structure of the geologic units extending from land surface through the lower Eocene formations.

4.0 References

Applin, P.L. and Applin, E.R, *Regional Subsurface Stratigraphy and Structure of Florida and Southern Georgia*, AAPG Bulletin, Volume 28, Issue 12, December 1944.

Applin, P.L. and Applin, E.R., 1965*, The Comanche Series and Associated Rocks in the Subsurface in Central and South Florida: United States Geological Survey Professional Paper 447, 82 p*

ArcGIS, *NAVD88 Ground Surface Elevations (ft)*
https://www.arcgis.com/home/webmap/viewer.html?layers=ca44a6a0714d4d3daa43eba592e8b11b

ASRUS and Reiss Engineering, 2014, *Engineering Report for the Construction and Testing of the Polk County Northwest Regional Wastewater Treatment Facility ASR Well System*, August 2014.

Arthur, J.D., *Petrogenesis of Early Mesozoic Tholeiite in the Florida Basement and an Overview of Florida Basement Geology*, Report of Investigations no. 97, Florida Geological Survey, 1988;

Crandall, C., 2007, *Hydrogeologic settings and ground-water flow simulation of the Northern Tampa Bay Regional Study Area*, Florida, section 5 of Paschke, S.S., ed., Hydrogeologic settings and ground-water flow simulations for regional studies of the transport of anthropogenic and natural contaminants to public-supply wells—studies begun in 2001: Reston, Va., U.S. Geological Survey Professional Paper 1737–A, pp. 5–1 – 5–30.Dallmeyer, R.D., A *Tectonic Linkage between the Rodelide Orogen (Sierra Leone) and the St. Lucie Metamorphic Complex in the Florida Subsurface*, The Journal of Geology, v. 97, no. 2, March 1989.

Tallahassee, Florida, & FDEP, *Class V Injection Well System, IW-1 - Notice of Draft Permit 1–32 (2019)*. Tallahassee, Florida; FDEP. FDEP UIC Permit No.: 0374375-001-UO/5Q K.C. Industries, LLC FDEP WACS Facility ID: 106032

Florida Department of Environmental Protection (2009, March 1). *Underground Injection Control (UIC) Class I Wells.* Florida Department of Environmental Protection Geospatial Open Data. Retrieved September 27, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-monitoring-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (1990, January 1). *Underground Injection Control Monitoring Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved March 2September 27, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-monitoring-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (2009, March 1). *Underground Injection Control (UIC) Class V ASR Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved March 2, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-uic-class-v-asr-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (2009, March 1). *Underground Injection Control (UIC) Class V Non-ASR Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved September 27, 2023, from Underground Injection Control (UIC) Class V Non-ASR Wells | Underground Injection Control (UIC) Class V Non-ASR Wells | Florida Department of Environmental Protection Geospatial Open Data (state.fl.us)

Florida Department of Environmental Protection (2014, November 5). *Permitted Oil and Gas Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved September 27, 2023, from Permitted Oil and Gas Wells | Permitted Oil and Gas Wells | Florida Department of Environmental Protection Geospatial Open Data (state.fl.us)

Florida Department of Environmental Protection (2020, November 5). Florida Geological Survey (FGS) Borehole. Florida Department of Environmental Protection Geospatial Open Data. Retrieved September 27, 2023, from Florida Geological Survey (FGS) Borehole | Florida Geological Survey (FGS) Borehole | Florida Department of Environmental Protection Geospatial Open Data (state.fl.us)

FDEP. (2023, August 23). *Subsidence Incident Reports Map*. Map direct V7. https://ca.dep.state.fl.us/mapdirect/?focus=fgssinkholes

Kinnaman, S.L., and Dixon, J.F., 2011, *Potentiometric surface of the Upper Floridan aquifer in Florida and parts of Georgia, South Carolina, and Alabama*, May – June 2010: U.S. Geological Survey Scientific Investigations Map 3182, 1 sheet.

South Florida Water Management District (2016, March 10). *DBHYDRO Wells and Boreholes*. SFWMD Open Data. Retrieved September 27, 2023, from DBHYDRO Wells and Boreholes | DBHYDRO Wells and Boreholes | South Florida Water Management District Open Data (arcgis.com) South Florida Water Management District Open Data. (n.d.). https://geo-sfwmd.hub.arcgis.com/

DBHYDRO Wells and Boreholes. (n.d.). https://geo-sfwmd.hub.arcgis.com/datasets/dbhydro-wells-and-boreholes/explore

FGS Geologic Data | Florida Department of Environmental Protection. (n.d.). https://floridadep.gov/fgs/data-maps/content/fgs-geologic-data

Water Resources of the United States—National Water Information System (NWIS) Mapper. (n.d.). https://maps.waterdata.usgs.gov/mapper/index.html

MWH, 2013a, *Well Completion Report for Injection Well IW-1 and DZMW-1*, prepared for the Tampa Electric Company, Polk Power Station, Polk County Florida, June 2013.

MWH, 2013b, *Well Completion Report for Injection Well IW-2 and DZMW-2*, prepared for the Tampa Electric Company, Polk Power Station, Polk County Florida, June 2013.MWH, 2015, Well Completion Report for the South Hillsborough County Aquifer Recharge Project (SHARP), prepared for the Hillsborough County Public Utilities Department, Hillsborough County Florida, February 2015.

Hickey, J. J., and Wilson, W. E., 1982, *Results of Deep-Well Injection Testing (KCI) at Mulberry*, Florida, United States Geological Survey Water Resources Investigations 81-75.

Roberts-Ashby, T. L., Stewart, M. T., & Ashby, B. N. (2013, September). *An evaluation of porosity and potential use for carbon dioxide storage in the Upper Cretaceous Lawson Formation and Paleocene Cedar Keys Formation of south-central and southern Florida*. Pubs.geoscienceworld.org. https://pubs.geoscienceworld.org/eg/article-abstract/20/3/109/138140/An-evaluation-of-porosity-and-potential-use-for-Formation of south-
central and southern Florida, Environmental Geosciences, V. 20, No. 3 (September 2013), pp. 109-135

Miller, J. A., 1986, *Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina*, U.S. Geological Survey Professional Paper 1403B.

Milton, C., *Igneous and Metamorphic Basement Rocks of Florida*, Bulletin 55, Florida Bureau of Geology, 1972.

Puri and Vernon, 1974; *Geologic Framework of the High Transmissivity Zones in South Florida*, Bureau of Geology, Special Publication No. 20, 101 p.

Reese, R. S. (1994). *Hydrogeology and the distribution and origin of salinity in the Floridan Aquifer System, Southeastern Florida.* Water-Resources Investigations Report. Retrieved March 6, 2023, from https://pubs.er.usgs.gov/publication/wri944010

Reese, R. S. and Richardson E., *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida*, U.S. Geological Survey Scientific Investigations Report 2007-5207, 2008.

Scott, T.M., 1988. *The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida*: Florida Geological Survey, Bulletin 59, 148 p

Scott, 1992, *A Geological Overview of Florida*, Florida Geological Survey, Open File Report No. 50, 81 p.

Williams, L.J., and Kuniansky, E.L., 2016, *Revised hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina* (ver. 1.1, March 2016): U.S. Geological Survey Professional Paper 1807, 140 p., 23 pls., http://dx.doi.org/10.3133/pp1807.

Submitted via Electronic Mail

March 15, 2024

Ronald McCulley
Florida Department of Environmental Protection
2600 Blair Stone Road MS 3500
Tallahassee, Florida 32399

Mosaic Fertilizer, LLC – Green Bay Bartow Facilities
Initial Application to Construct Class V Exploratory Injection Well
Polk County

Dear Mr. McCulley:

Please find attached herein an application for the Mosaic Fertilizer, LLC (Mosaic) Green Bay and Bartow Facilities (Facilities) for construction of a proposed Class V Exploratory Injection Well. The proposed exploratory well will be located within Polk County and will consist of the construction of one proposed exploratory injection well. Included with this package is a signed and sealed copy of FDEP Form 62-528.900(1). Check No. 203449 in the amount of $750.00 will be mailed separately to the Department to support the associated permit processing fee.

Mosaic has included the "Mosaic Green Bay Bartow Exploratory Well IW-1 Class V, Group 9, Exploratory Injection Well Construction Permit Application" which was prepared by our third-party consultant, Black & Veatch. This report provides the supporting information as required in the Florida Department of Environmental Protection (FDEP) Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems*. This application also previews information that will be submitted at a later date to potentially submit a Class I Well Construction Permit for the facilities utilizing information collected during the construction of the proposed Class V Exploratory Injection Well.

If you have any questions or require any additional information to assist in the review of this application, please contact me at (813) 541.4633 or by email at ben.koplin@mosaicco.com.

Sincerely,

Ben L Koplin
Sr Manager, Environmental

Encl: FDEP Form 62-528.900(1)
Delegation of Authority – Ms. Jody Hilderman
Mosaic Green Bay Bartow Exploratory Well IW-1 Class V, Group 9, Exploratory Injection Well Construction Permit Application

cc: John Coates, FDEP
Pat Kane, Mosaic
Jody Hilderman, Mosaic
Santino Provenzano, Mosaic
Dara Ford, Mosaic
Monica Tochor, Mosaic
Jackie Barron, Mosaic

MOSAIC GREEN BAY-BARTOW FACILITY EXPLORATORY WELL IW-1

Florida Department of Environmental Protection Class V, Group 9, Exploratory Injection Well Construction Permit Application

B&V PROJECT NO. 417558

PREPARED FOR

Mosaic Fertilizer, LLC

15 MARCH 2024

BLACK & VEATCH

CERTIFICATIONS

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

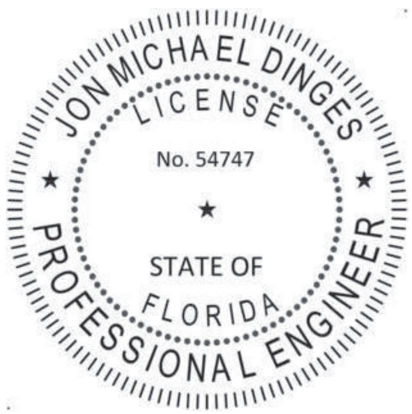
PROFESSIONAL ENGINEER

The engineering features of the Class V, Group 9, Exploratory Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, March 2024, were prepared by, or reviewed by, a Licensed Professional Engineer in the State of Florida.

Jon Dinges, P.E.

3/18/2024
Date

PE54747
License No.



PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the Class V, Group 9, Exploratory Injection Well Construction Permit Application for Mosaic Fertilizer, LLC, March 2024, were prepared by, or reviewed by, a Licensed Professional Geologist in the State of Florida.

Ed Rectenwald, P.G.

3/18/2024
Date

PG2469
License No.

Table of Contents

LIST OF TABLES

LIST OF EXHIBITS

LIST OF ACRONYMS AND ABBREVIATIONS

ASR	Aquifer Storage and Recovery
AOR	Area of Review
APPZ	Avon Park Permeable Zone
ASTM	American Society for Testing and Materials
BHCS	Borehole Compensated Sonic Log
bls	below land surface
BZ	Boulder Zone
CAL	Caliper Log
CBL	Cement Bond Log
DIL	Dual Induction Log
DZMW	Dual-Zone Monitoring Well
EOR	Engineer of Record
FAS	Floridan Aquifer System
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FGS	Florida Geological Survey
FM	Flowmeter Log
FR	Fluid Resistivity Log
FRP	Fiberglass Reinforced Plastic
ft	Feet
feet/min	Feet per minute
feet/sec	Feet per second
gpm	Gallons per minute
HRT	High Resolution Temperature Log
ICU	intermediate confining unit
ID	Inside diameter
IW	Injection Well
LCPZ	Lower Cretaceous Permeable Zone
LFA	Lower Floridan aquifer
LMZ	Lower Monitoring Zone
MCU	Middle Confining Unit
MGD	Million gallons per day
mg/L	Milligrams per Liter
MIT	Mechanical Integrity Testing
NAVD	North American Vertical Datum
NELAP	National Environmental Laboratory Accreditation Program
NGR	Natural Gamma Ray Log
NGVD	National Geodetic Vertical Datum
OD	Outside diameter
P&A	Plugging and Abandonment
PMW	Pad Monitoring Well
psi	Pounds per Square Inch
PVC	Polyvinyl chloride
RTS	Radioactive Tracer Survey
SAS	Surficial Aquifer System
SFCU	Sub-Floridan Confining Unit

SFWMD	South Florida Water Management District
SOP	Standard Operating Procedures
SP	Spontaneous Potential Log
SWFWMD	Southwest Florida Water Management District
TEMP	Temperature Log
TD	Total Depth
TDS	Total Dissolved Solids
TV	Color Video Survey
UCPZ	Upper Cretaceous Permeable Zone
UFA	Upper Floridan aquifer
UIC	Underground Injection Control
UMZ	Upper Monitoring Zone
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
VDL	Variable Density Log
WWTF	Wastewater Treatment Facility

Permit Application and Documentation Format

The information required in FDEP Form No. 62-528.900(1) *Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems* is included herein and is divided into the following sections:

Section 1 - FDEP Form No. 62-528.900(1) Application to Construct/Operate/Abandon Class V Well Systems. The executed Class V Exploratory Well Construction and Testing Permit application is contained in this section and addresses the specific information requested in Application Form 62-528.900(1).

Section 2 - Class V Exploratory Well Construction Supporting Data and Part F Responses to Part F of Form 62-528.900(1).

Section 3 - Supplemental Information for Future Class I Industrial Well Construction Permit Application. Section 3 provides additional information not specifically required for the Class V Exploratory Well Construction Permit. This is a preview of information that will be submitted for the Class I Well Construction Permit application and is provided here only as general information to help with expediting the Class V Well Construction Permit application review.

All project well schematics and figures are included in the Exhibits.

1.0 FDEP Application to Construct/Operate/Abandon Class I, III, or V Injection Well Systems

FDEP Rule No. 62- 528.900(1)] Forms for Underground Injection Control

Florida Department of Environmental Protection

Twin Towers Office Bldg., 2600 Blair Stone Road, Tallahassee, Florida 32399-2400

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No,:	
WACS#	(Filled in by DEP)

APPLICATION TO CONSTRUCT/OPERATE/ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

Part I. Directions

A. All applicable items must be completed in full in order to avoid delay in processing this application. Where attached sheets or other technical documentation are utilized in lieu of the blank space provided, indicate appropriate cross-reference in the space and provide copies to the Department in accordance with C. below. Where certain items do not appear applicable to the project, indicate N/A in the appropriate spaces.

B. All information is to be typed or printed in ink.

C. Two (2) copies of this application and two (2) copies of supporting information such as plans, reports, drawings and other documents shall be submitted to the appropriate Department office if submitted as a paper document, or one (1) copy of the application and one (1) copy of the plans, reports, drawings and other documents if the submittal is in an electronic format. An engineering report is also required to be submitted to support this application pursuant to the applicable sections of Rule 62-528, F.A.C. The attached list* shall be used to determine completeness of supporting data submitted or previously received. A check for the application fee in accordance with Rule 62-4.050, F.A.C., made payable to the Department shall accompany the application.

D. For projects involving construction, this application is to be accompanied by two (2) sets or one (1) set, in accordance with C. above, of engineering drawings, specifications and design data as prepared by a Professional Engineer registered in Florida, where required by Chapter 471, Florida Statutes.

E. Attach 8 1/2" x 11" site location map indicating township, range and section and latitude/longitude for the project.

PART II. General Information

A. Applicant Name Jody Hilderman Title General Manager, Bartow

Address 13830 Circa Crossing Drive

City Lithia State Florida Zip 33547

Telephone Number 863.348.7928 Email jody.hilderman@mosaicco.com

B. Project Status: ☑ New ☐ Existing

☐ Modification (specify) N/A

*"Engineering and Hydrogeologic Data Required for Support of Application to Construct, Operate and Abandon Class I, III, or V Injection Wells"

C. Well Type: ☑ Exploratory Well ☐ Test/Injection Well

D. Type of Permit Application

- ☐ Class I Test/Injection Well Construction and Testing Permit
- ☐ Class I Well Operation Permit
- ☐ Class I Well Operation Repermitting
- ☐ Class I Well Plugging and Abandonment Permit
- ☐ Class III Well Construction/Operation/Plugging and Abandonment Permit
- ☑ Class V Exploratory Well Construction and testing Permit
- ☐ Class V Well Construction Permit
- ☐ Class V Well Operation Permit
- ☐ Class V Well Plugging and Abandonment Permit
- ☐ Monitor Well Only

E. Facility Identification:

Name Mosaic Bartow Facility

Facility Location: Street 3200 Sr 60 W

City Bartow County Polk

SIC Code(s) 2874

F. Proposed facility located on Indian Lands: Yes ☐ No ☑

G. Well Identification:

Well No. IW-1 of 1 (total #) Wells *Multiple wells may be noted*

Purpose (Proposed Use) Injection of Pre-Treated, non-hazardous Process Water

Well Location: Latitude: See ° App ' Docs " Longitude: See ° App ' Docs "
(attach separate sheet(s), if necessary, for multiple wells)

Subpart B. General Project Description:

H. General Project Description: Describe the nature, extent and schedule of the injection well project. Refer to existing and/or future pollution control facilities, expected improvement in performance of the facilities and state whether the project will result in full compliance with the requirements of Chapter 403, F.S., and all rules of the Department. Attach additional sheet(s) if necessary or cross-reference the engineering report.

The proposed Exploratory Injection Well (IW-1) has been designed for the injection of pre-treated, non-hazardous industrial wastewater stored at the phosphogypsum stacks (gyp-stacks), the phreatic water collected by the gypstack underdrain systems, and associated process water. During construction of IW-1, the local hydrogeology will be investigated to confirm the properties of the target injection zone (Upper Cretaceous Permeable Zone) as compatible for injection of pre-treated wastewater.

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: .
DEP Application No,: .
WACS# (Filled in by DEP)

PART III. Statement by Applicant and Engineer

A. Applicant

I, the owner/authorized representative* of Mosaic Fertilizer, LLC certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I understand that this certification also applies to all subsequent reports submitted pursuant to this permit. Where construction is involved, I agree to retain the design engineer, or other professional engineer registered in Florida, to provide inspection of construction in accordance with Rule 62-528.455(1)(c), F.A.C.

Signed

Date: March 14, 2024

Jody Hilderman, General Manager, Bartow

Name and Title (Please Type)

863.348.7928

Telephone Number

*Attach a Letter of Authorization.

B. Professional Engineer Registered in Florida

This is to certify that the engineering features of this injection well have been designed/examined by me and found to be in conformity with modern engineering principles applicable to the disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgement, that the well, when properly maintained and operated, will discharge the effluent in compliance with all applicable statutes of the State of Florida and the rules of the Department. It is also agreed that the undersigned will furnish the applicant a set of instructions for proper maintenance and operation of the well or ensure they have been furnished.

JON MICHAEL DINGES
LICENSE
No. 54747
STATE OF FLORIDA
PROFESSIONAL ENGINEER

(Please Affix Seal)

Signed

Jon M. Dinges

Name (Please Type)

Black & Veatch

Company Name (Please Type)

1715 N. Westshore Boulevard, Suite 725, Tampa, FL 33607

Mailing Address (Please Type)

Florida Registration No. PE No. 54747 Date 3/18/2024 Phone No. 386-361-537

Email of P.E.: dingesj@bv.com

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No,:	
WACS#	(Filled in by DEP)

ENGINEERING AND HYDROLOGIC DATA REQUIRED FOR SUPPORT OF APPLICATION TO CONSTRUCT, OPERATE, AND ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

The following information shall be provided for each type of permit application.

N/A **A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT**

1. A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data.

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program.

15. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

N/A **B. CLASS I INJECTION WELL OPERATION PERMIT**

1. A report shall be submitted with each application for a Class I Well operating permit, which shall include, but not be limited to, the following information:

   (a) Results of the information obtained under the construction permit described in A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT, including:

      (1) All available logging and testing program data and construction data on the well or well field;

      (2) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C;

      (3) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

      (4) The actual injection procedure;

      (5) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone; and,

      (6) The status of corrective action on defective wells in the area of review.

   (b) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

   (c) Certification of completion submitted by the engineer of record;

   (d) If requested by the Department, operation manual including emergency procedures;

   (e) Proposed monitoring program and data to be submitted;

(f) Proof that the existence of the well has been recorded on the surveyor's plan at the county courthouse; and,

(g) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

N/A **C. CLASS I WELL OPERATION REPERMITTING**

1. An updated map showing the location of the injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of pubic record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the injection zone, confining zone, or monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

7. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

8. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

9. A report shall be submitted with each application for repermitting of Class I Well operation which shall include the following information:

   (a) All available logging and testing program data and construction data on the well or well field;

(b) A satisfactory demonstration of mechanical integrity for all wells pursuant to Rule 62-528.300(6), F.A.C.;

(c) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

(d) The actual injection procedure;

(e) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone;

(f) The status of corrective actin on defective wells in the area of review;

(g) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

(h) Certification of completion submitted by the engineer of record;

(i) An updated operation manual including emergency procedures;

(j) Proposed revisions to the monitoring program or data to be submitted; and,

(k) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

N/A **D. CLASS I WELL PLUGGING AND ABANDONMENT PERMIT**

1. The reasons for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods, and justification for use.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

N/A **E. CLASS III WELLS CONSTRUCTION/OPERATION/PLUGGING AND ABANDONMENT PERMIT**

Construction Phase

1. A map showing the location of the proposed injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water system, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data:

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids, including any additives.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures or catastrophic collapse, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, and a drilling, testing and coring program.

15. A certificate that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

16. Expected changes in pressure, native fluid displacement, direction of movement of injection fluid.

17. A proposed monitoring plan, which includes a plan for detecting migration of fluids into underground sources of drinking water, a plan to detect water quality violation in the monitoring wells, and the proposed monitoring data to be submitted.

Operation Phase

1. The following information shall be provided to the Department prior to granting approval for the operation of the well or well field:

   (a) All available logging and testing program data and construction data on the well or well field;

   (b) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C.;

   (c) The actual operating data, including injection pressure versus pumping rate where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

   (d) The results of the formation testing program;

   (e) The actual injection procedure; and,

   (f) The status of corrective action on defective wells in the area of review.

Plugging and abandonment Phase

1. The justification for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods.

    (a) The type and number of plugs to be used;

    (b) The placement of each plug including the elevation of the top and bottom;

    (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

    (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT

1. Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.

2. Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

3. Proposed other uses of the exploratory well.

4. Drilling and testing plan for the exploratory well. The drilling plan must specify the proposed drilling program, sampling, coring, and testing procedures.

5. Abandonment Plan.

N/A **G. CLASS V WELL CONSTRUCTION PERMIT**

(This form should be used for Class V Wells instead of Form 62-528.900(3), F.A.C., when there is a need for a Technical Advisory Committee and an engineering report.)

1. Type and number of proposed Class V Wells:

________ Wells Receiving Domestic Waste

________ Desalination Process Concentrate Wells (Reverse Osmosis, etc.)

________ Aquifer Storage and Recovery Wells

________ Aquifer Remediation Wells

________ Salt-water Intrusion Barrier Wells

________ Cooling Water Return Flow Wells Open-looped System

________ Subsidence Control Wells

________ Aquifer Recharge Wells

________ Experimental Technology Wells

________ Wells used to inject spent brine after halogen recovery

________ Radioactive Waste Disposal Wells*

________ Borehole Slurry Mining Wells

________ Other non-hazardous Industrial or Commercial Disposal Wells

(explain) ________________________________

________ Other (explain) ________________________________

*Provided the concentrations of the waste do not exceed drinking water standards contained in Chapter 62-550, F.A.C.

2. Project Description:

   (a) Description and use of proposed injection system;

   (b) Nature and volume of injected fluid (the Department may require an analysis including bacteriological analysis) in accordance with Rule 62-528.635(2)(b), F.A.C.; and,

   (c) Proposed pretreatment.

3. Water well contractor's name, title, state license number, address, phone number and signature.

4. Well Design and Construction Details. (For multi-casing configurations or unusual construction provisions, an elevation drawing of the proposed well should be attached.)

   (a) Proposed total depth;

   (b) Proposed depth and type of casing(s);

   (c) Diameter of well;

   (d) Cement type, depth, thickness; and,

   (e) Injection pumps (if applicable): ____________ gpm @ ____________ psi

   Controls: ____________________

   ____

   ____

5. Water Supply Wells - When required by Rule 62-528.635(1), F.A.C., attach a map section showing the locations of all water supply wells within a one-half (1/2) mile radius of the proposed well. The well depths and casing depths should be included. When required by Rule 62-528.635(2), F.A.C., results of bacteriological examinations of water from all water supply wells within one-half (1/2) mile and drilled to approximate depth of proposed well should be attached.

6. Area of review (When required by Rule 62-528.300(4), F.A.C.)

   Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

N/A **H. CLASS V WELL OPERATION PERMIT**

(Final report of the construction that includes the following information may be submitted with the application to operate.)

1. Permit Number of Class V Construction Permit: ____________________

2. Owner's Name: ____________________

3. Type of Wells: ____________________

DEP Form No: 62-528.900(1)
Form Title: Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date: ____________.
DEP Application No,: ____________.
WACS#____________(Filled in by DEP)

4. Construction and Testing Summary:

   (a) Actual Dimensions:

Diameter	(inches)	Well Depth	(feet)	Casing Depth	(feet)

   (b) Result of Initial Testing

5. Proposed Operating Data:

   (a) Injection Rate (GPM);

   (b) Description of injected waste; and,

   (c) Injection pressure and pump controls.

6. Proposed Monitoring Plan (if any):

   (a) Number of monitoring wells;

   (b) Depth(s);

   (c) Parameters;

   (d) Frequency of sampling; and,

   (e) Instrumentation (if applicable) Flow ____________

   Pressure ____________

N/A **I. CLASS V WELLS PLUGGING AND ABANDONMENT PERMIT**

1. Permit number of Class V construction or operating permit.

2. Type of well.

3. Proposed plugging procedures, plans and specifications.

4. Reasons for abandonment.

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	.
DEP Application No,:	.
WACS#______________	(Filled in by DEP)

N/A **J. MONITOR WELL PERMIT**

This section should be used only when application is made for a monitor well only. If a monitor well is to be constructed under a Class I, III, or V injection well permit, it is not necessary to fill in this section.

1. A site map showing the location of the proposed monitor wells for which a permit is sought. The map must be to scale and show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, water wells and other pertinent surface features including structures and roads.

2. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

3. Maps and cross sections detailing the hydrology and geologic structures of the local area.

4. Generalized maps and cross sections illustrating the regional geologic setting.

5. Proposed formation testing program to obtain an anlysis of the chemical, physical and radiological characteristics of and other information on the monitor zone(s).

6. Proposed monitoring procedure.

7. Engineering drawings of the surface and subsurface construction details of the monitoring system.

8. Proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

9. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program

10. Monitor Well Information:

☐ On-site ☐ Multizone ☐ Single-zone

☐ Regional ☐ Other (specify) ______________________

Proposed Monitoring Interval(s) ______________________

Distance and Direction From Associated Injection Well

____

CERTIFICATE OF OFFICER
OF
MOSAIC FERTILIZER, LLC
AS TO AUTHORIZATION

The undersigned, Bruce M. Bodine, does hereby certify that he is the duly elected Senior Vice President – North America of Mosaic Fertilizer, LLC, a Delaware Limited Liability Company (the "**Company**") and further certifies as follows:

1. Jody Hilderman, in her capacity as General Manager – Bartow for the Company, is authorized to execute and submit all routine environmental reports, permit applications and follow-up responses for the Bartow, Green Bay and South Pierce facilities, including as the duly authorized representative for Title V and NPDES permits, where the signature of an officer is not otherwise mandated by law, statute or regulation.

2. The signature appearing opposite Ms. Hilderman's name is a true and correct specimen of her signature:

NAME:	TITLE:	SIGNATURE:
Jody Hilderman	General Manager – Bartow	J Hilderman

In witness whereof, the undersigned has executed this document effective this 24th day of August 2022.

Bruce Bodine

Bruce M. Bodine
Senior Vice President – North America

Subscribed and sworn to before me this 24 day of August 2022.

Notary Public

AMBER MARIE ENGLISH
Notary Public - State of Florida
Commission # GG 353980
My Comm. Expires Jul 17, 2023
Bonded through National Notary Assn.

NOTARY PUBLIC STATE OF FLORIDA

2.0 Class V Exploratory Well Construction Permit Supporting Data

(Responses to Part F of Form 62-528.900(1))

The following addresses the information required in FDEP UIC permit application (FDEP Form 62-528.900(1)), page 10, Section F "EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT". The permit application required information is shown in bold type followed by the supporting technical information.

F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT

1. **Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.**

Injection Well Hydraulic Design Criteria

The proposed Class V Exploratory Injection Well (IW-1) has been designed for the injection of pre-treated, non-hazardous industrial wastewater staged at Mosaic Fertilizer, LLC's (Mosaic) Green Bay and Bartow Facilities (FDEP Wastewater Permits FL0001589 and FL0000752) phosphogypsum stacks (gyp-stacks), from phreatic water collected by the gypstack underdrain systems, and associated pre-treated process water(s). The phreatic water, or gypsum stack pore water, collected in the underdrain system is not considered a separate waste stream and is characteristically similar to ponded process water. The water collected in the underdrain system is returned to the gypstack and will be comingled with the process water that will go through pre-treatment.

During construction of Well IW-1, the local hydrogeology will be investigated to confirm the properties of the target injection zone (Upper Cretaceous Permeable Zone [UCPZ] as compatible for injection of pre-treated wastewater from both Facilities. The location of Mosaic's Facilities is shown in **Exhibit 1**. The location for Well IW-1 is shown in **Exhibit 2**.

As shown in **Exhibit 3**, the injection well will be constructed with a 20-inch outside diameter (OD), 0.500-inch wall, final seamless steel casing. A nominal 10.72-inch inside diameter (ID) RedBox 1250 FRP injection tubing with cementing packer will be installed and cemented inside the 20-inch OD final seamless steel casing. In accordance with fluid velocity limitations for the injection well, the design injection capacity is approximately 2,775 gallons per minute (gpm) (or 4.00 Million Gallons per Day [MGD]) at 10 feet per second (ft/sec). The proposed injection well system will include a dual-zone monitoring well (DZMW-1) for continuous monitoring of the hydraulic head and water quality within two completed monitoring zones, above and below the underground source of drinking water (USDW).

Following construction and initial testing of IW-1 and DZMW-1, Mosaic will seek to re-classify the exploratory well to a UIC Class I industrial injection well for operational testing. The Class I well will facilitate long-term water management and support the site closure strategy. In the event of a well shut-in, the Facilities will maintain permitted options for managing wastewater using a Reverse Osmosis system, onsite lime treatment or transferring to other Mosaic facilities in accordance with NPDES authorizations, or other permitted treatment and disposal options, until UIC can be resumed.

As shown in **Exhibit 3**, Well IW-1 is designed as a multi-stage cased well with a total depth (TD) of approximately 5,250 feet below land surface (bls). Well IW-1 will be constructed with five telescoped steel casings (diameters 60-inch, 50-inch, 40-inch, 30-inch, and 20-inch) installed to isolate individual groundwater production zones as the well is drilled to depth, as shown in **Exhibit 4**. All steel casings installed during construction of the well will be cemented to land surface with type II or IL cement. The final casing depth is estimated to be 4,060 feet bls. The well is planned to be drilled to TD estimated at 5,250 feet bls and completed with an open hole injection zones in the Upper Cretaceous Permeable Zone (UCPZ) of the Cedar Keys Formation and the underlying Lawson Limestone. Mosaic will confer with FDEP about potential changes to the injection zone based on findings through exploratory drilling.

The base of the USDW (groundwater having a total dissolved solids concentration of less than 10,000 milligrams per liter [mg/L]) was identified approximately 5.3 miles to the east at a depth of 2,794 feet bls at the KC Industries during construction of its Class V Exploratory Injection Well IW-1 (KCI, 2019). Based on this information and hydrogeological data obtained from other nearby wells, it is anticipated that the base of the USDW may occur at approximately 2,860 feet bls at the proposed location for this injection well system. The 30-inch OD intermediate carbon steel casing and 20-inch OD final seamless steel casing for Well IW-1 is designed to extend below the base of the USDW and will be adjusted to accommodate local geological findings as the well is constructed.

During well construction cementing activities, and subject to the Department's approval, Mosaic may use an American Society for Testing and Materials (ASTM) C595M-21PLC/Type 1L cement with up to 6% bentonite or higher, by weight. Type II or IL neat cement will be used to cement the 60-inch, 50-inch, and 40-inch OD carbon steel casings from their bases back up to ground surface. Type II or IL neat cement will be used to cement the 30-inch and 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing from their bases in the casing-to-formation intervals and below the USDW. Type II or IL cement with up to 6% bentonite by weight may be used to cement the casing-inside-casing intervals above the USDW to ground surface for the 30-inch and 20-inch OD casings and the 10.72-inch ID RedBox 1250 FRP injection tubing.

Since Well IW-1 is designed to meet the construction requirements for a Class 1 industrial injection well, a packer assembly will be installed to isolate the nominal 10.72-inch ID RedBox 1250 FRP injection tubing within the 20-inch OD final seamless steel casing. The annulus between the 20-inch OD final seamless steel casing and the nominal 10.72-inch ID RedBox 1250 FRP injection tubing will be cemented back to ground surface.

To expedite UIC permitting and construction schedule, IW-1 will be initially permitted as a UIC Class V Exploratory Well (Class V, Group 9), to evaluate the UCPZ of the Cedar Keys Formation and the underlying Lawson Limestone for injection. Upon completion of drilling and testing, and prior to any operational injection testing, Mosaic will submit a new UIC well construction permit application to reclassify the permitting Class V exploratory well as a UIC Class I Industrial injection well.

Dual-Zone Monitor Well (DZMW-1) Design

Following the completion of drilling and testing at the Class V Exploratory Well IW-1 to the proposed depth of the Lower Monitoring Zone (LMZ) for the dual-zone monitoring well (DZMW-1), construction of DZMW-1 may begin. This strategy will provide all the necessary information to construct DZMW-1. DZMW-1 will be constructed for continuous monitoring of the hydraulic head within two isolated monitoring zones (Upper Monitoring Zone [UMZ] and LMZ). The UMZ will be located above the base of the USDW and the LMZ will be located just above the principal confining strata and below the base of the USDW, based on

local ambient water quality conditions. Well DZMW-1 will also be used for collection of groundwater samples for laboratory analysis during injection well operation. As shown on **Exhibit 3**, the UMZ is anticipated to be constructed from approximately 2,075 feet to 2,200 feet bls and the LMZ from approximately 2,970 feet to 3,070 feet bls, respectively.

The exact monitoring intervals will be confirmed during the construction of Well IW-1. Following interval testing during the drilling of Well DZMW-1, groundwater quality will be evaluated, and the results provided to FDEP for final monitoring interval selection and approval.

DZMW-1 will be designed with pumps and piping to facilitate purging and collection of groundwater samples produced from the monitoring zones for disposal in the injection well or to the pre-treatment pump station for eventual disposal in the injection well. The final design will be contingent upon the drilling and testing results of Wells IW-1 and DZMW-1.

Permit specified groundwater quality analyses and hydraulic head (elevation in feet) will be conducted in both monitoring zones (upper and lower) of Well DZMW-1. Upon FDEP's approval to commence operational testing, the collected data will be electronically measured and recorded for submittal, including the monthly operating reports of Well DZMW-1.

Shallow Pad Monitoring Well Design (For Monitoring During Construction)

Four (4) shallow pad monitoring wells (PMWs) are proposed, which will surround Well IW-1, for Surficial Aquifer System (SAS) water level and water quality monitoring as shown in **Exhibit 2**. The locations of these shallow PMWs will be submitted to FDEP for approval prior to their installation and initiation of installation activities. Construction details of the PMWs are detailed in **Exhibit 5**.

Proposed Instrumentation and Control (For Future Class I Permit)

A preliminary wellhead drawing for Wells IW-1 and DZMW-1 is provided in **Exhibit 6**. The preliminary process flow diagram that shows the interrelationship of the well, pumping station, and monitoring and control instrumentation will be provided with the UIC Class I Well Construction Permit Application submittal, at a later date.

Proposed Monitoring for Operational Testing (For Future Class I Permit)

Following the construction and testing of Exploratory Well IW-1 and DZMW-1, Mosaic expects to seek to re-classify the injection well system as a UIC Class I industrial injection well for operational testing. Once in service, an approved monitoring program will commence which will include the required operational data and water quality sampling in accordance with the Class I well construction permit.

The Facilities' wastewater intended for injection will undergo pre-treatment, including to adjust the water chemistry for compatibility with the subsurface formations. As required for the Class I re-classification, an initial waste stream analysis of the pre-treated process water will be collected for the following water quality parameters prior to operation:

- Primary Drinking Water Standards. (*Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only in the initial waste stream analysis*);
- Secondary Drinking Water Standards; and Wastewater Quality Indicators

Drilling Containment Pad

During drilling and testing, each of the wells, IW-1 and DZMW-1, will be isolated within temporary fabricated-steel (or equivalent) fluid containment pads beneath the drilling rigs and substructures. Temporary fabricated-steel (or equivalent) secondary containment pads will be used beneath the mud tanks, pumps and fuel tanks. Mosaic will submit final designs of the fluid containment pads to FDEP for approval prior to the initiation of construction activities.

2. **Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.**

The proposed Injection Well System will be located in Polk County, Florida, as shown in **Exhibit 2.** Mosaic continues to evaluate potential locations at the Facilities for the system siting. Preliminary primary location coordinates for both Wells IW-1 and DZMW-1 are shown below in **Tables 2-1**. Preliminary secondary location coordinates for both are shown below in **Table 2-2. Exhibit 2** displays proposed primary and secondary well locations. The calculations presented in **Exhibit 7A** indicate that the injected fluids could theoretically migrate a radius of approximately 3,940.99 feet (0.75 miles) over a 10-year period (two permit durations), assuming that the deep injection well will operate at a maximum continuous injection rate of approximately 4.00 MGD. **Exhibit 7B** provides a plot of the theoretical effective radial distance of influence over time. The injectate front calculation assumes a conservative injection zone thickness of 200 feet and an effective porosity of 0.20 (dimensionless) based on current FDEP guidance.

Table 2-1 Proposed Primary Location for Wells IW-1 and DZMW-1

Well ID	Latitude	Longitude
Class V Exploratory Well IW-1 (Proposed)	27° 52' 37.17001" N	81° 54' 20.77999" W
Dual-Zone Monitoring Well DZMW-1 (Proposed)	27° 52' 37.18956" N	81° 54' 19.31796" W

Table 2-2 Proposed Secondary Location for Wells IW-1 and DZMW-1

Well ID	Latitude	Longitude
Class V Exploratory Well IW-1 (Proposed)	27° 51' 54.26039" N	81° 54' 56.94224" W
Dual-Zone Monitoring Well DZMW-1 (Proposed)	27° 51' 53.24472" N	81° 54' 55.8801" W

Using a conservative 1-mile radius from each of the two potential well siting areas the Facilities along with the AOR, major roads and surface water bodies are shown in aerial maps in **Exhibit 8** and **Exhibits 10A through 10J**. The proposed locations for Well IW-1 site have and average land surface elevation of approximately 200 feet above the North American Vertical Datum of 1988 (NAVD 88) (ArcGIS, 2020), as

shown in **Exhibit 1.** The Facilities are located in a rural area and approximately 30 miles inland from seawater (i.e., Hillsborough Bay).

Mosaic has performed detailed investigations to locate all wells that extended through and below the SAS within the AOR. These retired wells have been systematically plugged and abandoned to State standards per Chapter 40D-3, Florida Statutes. A comprehensive review of multiple public well permit databases was completed to identify all wells within the AOR for this application. Many of the wells are represented in multiple databases, and sometimes even within the same database given both construction and abandonment permits for the same well are represented as individual permit actions. Well permits within the public domain databases from the United States Geological Survey (USGS), Florida Geological Survey (FGS) Bureau of Mining and Minerals, Florida Department of Environmental Protection (FDEP), South Florida Water Management District (SFWMD) and Southwest Florida Water Management District (SWFWMD) were reviewed. A total of 1,567 wells and permits were identified within the AOR. **Exhibit 9** provides a tabulation of well permits found within the AOR; the permits are indexed and presented on the aerial maps shown in **Exhibits 10A** through **10I**. It should again be noted that some of the wells in the inventory may be duplicated due to the nature of extracting data from numerous databases and therefore, **Exhibit 9** provides a total tabulation of well permits from each database. Exhibits are outlined as follows:

- **Exhibits 9**: Tabulation of Wells and permits found within the AOR;
- **Exhibit 10A**: FGS Database Wells within the AOR;
- **Exhibit 10B**: USGS Database Wells within the AOR;
- **Exhibit 10C**: SFWMD and SWFWMD Database of Well permits within the AOR;
- **Exhibit 10D**: FDEP Database UIC Monitoring Wells within the AOR;
- **Exhibit 10E**: FDEP Database UIC Class V Non-ASR Wells within AOR;
- **Exhibit 10F**: FDEP Database UIC Class V ASR Wells within AOR;
- **Exhibit 10G**: FDEP Database UIC Class I Wells within the AOR;
- **Exhibit 10H**: Oil and Gas Database Wells within the AOR;
- **Exhibit 10I:** Mosaic's Well Inventory within the AOR;

There are no wells known to be improperly abandoned and none of the well construction permits identified within the AOR indicate penetration depths within a magnitude of order to the proposed injection or confining zones. The deepest well in the AOR is "365045 – 1", an industrial water supply production well that has a total depth of 1,140 feet bls; therefore, no wells penetrate the depths of the proposed UMZ (2,075 feet to 2,200 feet bls), the LMZ (2,970 feet to 3,070 feet bls) or injection zone (beginning at approximately 4,060 feet bls). **Table 2-3** and **Table 2-4** summarize the wells in the AOR and are separated by agency database, well type, and maximum depth.

Table 2-3 Summary of Wells per Database Inside AOR

Agency	Monitor/ Test/ Stratigraphic/ Dewatering	Water Supply (Domestic/Public/ Industrial/Fire/ Irrigation/Livestock/Mining)	Remediation /Repair or Deepen/Sealing Water	Plugged & Abandoned	Unknown	Total
FGS	5	7	-	-	8	20
USGS	11	-	-	-	-	11
SWFWMD/ SFWMD	1,029	91	79	266	35	1,500
FDEP	8	-	-	28[1]	-	36
Total	**1,053**	**98**	**79**	**294**	**43**	**1,567**

[1] Non-ASR Class V Injection Wells

Table 2-4 below summarizes the maximum depths of the wells identified within the AOR. Plugged and abandoned wells and proposed wells are included in the summary.

Table 2-4 AOR, Summary of Wells Maximum Depth (feet bls)

Agency	Monitor/ Test/ Stratigraphic/Dewatering	Water Supply (Domestic/Public/ Industrial/Fire/ Irrigation/Livestock/Mining)	Remediation /Repair or Deepen/Sealing Water	Plugged & Abandoned	Unknown	Maximum Depth (feet bls)
FGS	640	832	-	-	840	840
USGS	760	-	-	-	-	760
SWFWMD/SFWMD	854	1,140	785	830	832	1,140
FDEP[1]	-	-	-	615	-	615
Maximum Depth	**854**	**1,140**	**785**	**830**	**840**	**1,140**

[1] Monitoring wells associated with the facility ID No. 50804 from the FDEP database have no depths reported.

FGS Well Inventory

In the FGS database, shown in **Exhibit 10A**, 20 wells are documented within the AOR for this well survey. The 20 wells identified in the AOR were classified as:

- 5 Industrial wells
- 5 Stratigraphic wells
- 8 Unknown wells
- 1 Landscape Irrigation well
- 1 Public Supply well

These wells vary in total depth from 20 feet to 840 feet. The deepest documented well is owned and operated by Mosaic and is located within the boundary of the Facilities. Based on the location and depths of these wells, they are not expected to be affected by the operation of the proposed IW system.

USGS Well Inventory

In the USGS database, shown in **Exhibit 10B**, 11 wells are documented within the AOR for this well survey. The 11 wells identified in the AOR were classified as inactive groundwater monitoring wells.

The wells identified in the USGS inventory range from 119 feet to 760 feet bls with the deepest well located within the boundary of the Facilities. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

SWFWMD / SFWMD Well Permit Inventory

A total of 1,500 wells were identified within the AOR in the SWFWMD/SFWMD wells inventory, shown in **Exhibit 10C**. The 1,500 wells identified in the AOR were classified as:

- 949 Monitor
  - 339 of these are Proposed Well Construction Permits (WCP) Wells
- 266 Plugged
  - 113 of these are Proposed WCP Wells
- 54 Remediation – Recovery
  - 49 of these are Proposed WCP Wells
- 47 Test
  - 3 of these are Proposed WCP Wells
- 39 Domestic
- 35 Unknown
- 33 Dewatering
  - 32 of these are Proposed WCP Wells
- 20 Industrial
- 17 Sealing Water
- 13 Public Supply
  - 6 of these are Proposed WCP Wells
- 12 Irrigation
  - 3 of these are Proposed WCP Wells
- 8 Repair or Deepen
- 4 Mining
- 2 Essential Services (Fire Protection)

- 1 Livestock - Proposed WCP Well

The wells identified range from 5 feet to 1,140 feet bls in total depth with the deepest well located within the boundary of the Facilities. The deepest documented well is owned and operated by Mosaic. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

FDEP Well Inventory

A total of 36 wells were identified within the 1-mile AOR in the FDEP well inventory:

- 8 Monitoring well (**Exhibit 10D**). This exhibit currently displays 3 wells due to the following wells share the same coordinates:
  - MW-6 and MW-5
  - MW-2A, Well #1, and Well #2
  - MW-4A, Well #3, and Well #4
- 28 Class V non-aquifer storage and recovery (ASR) well (**Exhibit 10E**)
- 0 Class V ASR well (**Exhibit 10F**)
- 0 Class I Industrial Injection well (**Exhibit 10G**)
- 0 Oil and Gas permitted well (**Exhibit 10H**)

It is important to note that of the 36 wells identified in this database, 17 have no reported depths. Among the wells with recorded depths, the values vary from 150 feet to 615 feet bls as total depth with the deepest well located within the boundary of the Facilities. The deepest documented well is owned and operated by Mosaic. Based on the location and depth of these wells, they are not expected to be affected by the operation of the proposed IW System.

Mosaic Inventory

A total of 954 Mosaic wells were identified within the AOR. These wells are shown within the well inventories of the FGS (12 wells), USGS (5 wells), SWFWMD/SFWMD (909 wells), and FDEP (28 wells) and are shown in **Exhibit 10I**. The owner of these wells, Mosaic, is identified in the well inventories under various names such as International Minerals & Chemical, C F Chemicals Inc., CF Industries Inc., Cargill, Central Phosphates Inc., among others.

Table 2-5 below summarizes the Mosaic wells within the AOR databases. Plugged & abandoned wells and proposed wells are included in the summary.

Table 2-5 Summary of Mosaic Wells per Database Inside AOR

Agency	Monitor/ Test/ Stratigraphic /Dewatering	Water Supply (Domestic/Public/ Industrial/Fire/ Irrigation/Livestock/ Mining)	Remediation /Repair or Deepen/Sealing Water	Plugged & Abandoned	Oil and Gas Exploration	Unknown	Total
FGS	3	4	-	-	-	5	12
USGS	5	-	-	-	-	-	5
SWFWMD /SFWMD	654	19	74	145	-	17	909
FDEP	-	28	-	-	-	-	28
Total	**662**	**50**	**74**	**145**	**-**	**17**	**954**

3. **Proposed other uses of the exploratory well.**

4. Well IW-1 will be completed to meet the (F.A.C.) Rule 62-528 Class I Industrial injection well design, operation, and monitoring criteria. Following completion of IW-1 construction and testing, Mosaic will seek to re-classify the exploratory well to a UIC Class I industrial injection well, and will provide additional technical data, revised plugging and abandonment cost estimates, and financial assurance to support the proposed change. The purpose of IW-1 is to obtain site specific geology, water quality and confinement characteristics to determine the ideal interval for the injection of pre-treated, non-hazardous process water. **Drilling and testing plan for the exploratory well. The drilling plan must identify the proposed drilling program, sampling, coring, and testing procedures.**

The following section provides an overview of the construction program for the Well IW-1, and associated PMWs. The drilling and testing program for the Well IW-1, and associated PMWs will include information on cementing and casing programs, geophysical logging schedule, lithologic sampling, coring, packer testing, injection testing, and other hydrogeologic data collection procedures. These activities are detailed in **Exhibit 11A**. Pilot holes throughout the construction sequence shown below will be used to verify and validate the application information obtained from maps and cross-sections detailing the local area's hydrology and geologic structures. Information from the pilot holes will be then used to adjust casing set depths and design the well accordingly.

As shown in **Exhibit 11A and 11B**, during all pilot holes for the construction of Wells IW-1 and DZMW-1, lithologic samples will be collected every 10 feet. Additionally, mechanical deviation surveys will be collected at 90-foot intervals. Once construction switches from direct mud rotary drilling to reverse air drilling method, reverse air water quality samples will be collected at 45-foot intervals. Geophysical logging will be completed at the completion of every pilot hole and reamed hole. For hydrogeological testing and analysis above and below the base of the USDW, a 12.25-inch diameter pilot-hole will be drilled in multiple stages and tested to an estimated depth of approximately 5,250 feet bls. Core sampling and packer testing at Wells IW-1 and Well DZMW-1 will be conducted to evaluate the subsurface hydrogeology. This information will provide data to properly design Well IW-1 regarding the final casing seat depths and total borehole depth along with the associated Well DZMW-1 monitoring zones.

A steel (or equivalent as approved by the FDEP) fluid containment pad beneath the drill rig and rig substructure with secondary containment beneath mud tanks, mud pumps and fuel tanks will be built

prior to commencing drilling at the Well IW-1 location to contain drilling fluids and to prevent water quality impacts to the SAS. Additionally, a National Environmental Laboratory Accreditation Program (NELAP) certified laboratory will be available to sample and analyze (in accordance with FDEP Standard Operating Procedures [SOPs]) the PMWs throughout construction and testing to confirm no water quality impacts to the SAS.

The proposed work sequence for the mobilization and site preparation will be as follows:

1. Install temporary water, sewer, electrical, wireless internet, and cell phone services.

2. Conduct a pre-construction video survey of the site to document existing site conditions.

3. Perform site preparation: clearing, grubbing, stripping and debris removal. Remove and dispose of non-hazardous debris and build up soil sub-base for drilling pad.

4. Drill a pilot hole to confirm the base of the surficial aquifer. The casing seat depth of the 60-inch OD (wall thickness to be determined) pit carbon steel casing will terminate in the confining unit (Intermediate Confining Unit) for isolation of the Surficial Aquifer and stabilize shallow unconsolidated sediments for drilling operations. The casing seat depth will be determined by the Contractor and reviewed and approved by the Project Geologist/Engineer prior to its installation. Excavate fill materials and install a 60-inch OD (wall thickness to be determined) pit carbon steel casing to the depth required for the drilling system; the Project Geologist/Engineer will oversee the installation of the pit casing. The final floor elevation within the pit casing will accommodate the installation of a rotating head or other sealing mechanisms to control fluids during drilling. Excavated materials shall be stockpiled onsite.

5. Construct a temporary fabricated steel (or equal) fluid containment pad.

6. Install, develop, and sample four 4-inch diameter polyvinyl chloride (PVC) shallow PMWs at approved locations, as required by the FDEP. PMW locations are shown in **Exhibit 2** and PMW construction details are show in **Exhibit 5**. A NELAP certified laboratory will be utilized to conduct analyses on background samples collected at the PMWs.

7. Mobilize drilling and other required materials and equipment required for construction.

The sequential description of construction, well drilling and testing activities associated with Well IW-1 is shown below. **Exhibit 11A** provides a summary of testing to be conducted while drilling the Class V Exploratory Well IW-1.

1. Drill a pilot hole with a 12.25-inch diameter bit to approximately 550 feet bls using the direct mud-rotary method. Record mechanical deviation surveys and collect rock formation samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

2. Conduct geophysical logging [Caliper (CAL), natural gamma-ray (NGR), spontaneous potential (SP), dual-induction (DIL), borehole compensated sonic w/ variable density log (BHCS/VDL) and Acoustic Borehole Imager (ABI)] in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

3. Ream the pilot hole to a nominal 60-inch diameter borehole to approximately 505 feet bls using the direct mud-rotary method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

4. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

5. Install the 50-inch OD surface carbon steel casing to approximately 500 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**, and cement to surface. Conduct geophysical logging [Temperature (TEMP) and NGR] after each cement stage in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1** to confirm top of cement in conjunction with measurement from tremie pipe hard tags.

6. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

7. Drill out cement plug and drill a pilot hole centered at the bottom of the 50-inch OD surface carbon steel casing with a 12.25-inch diameter bit to approximately 1,250 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

8. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, color video survey (TV) or Optical Borehole Imager (OBI) or ABI, TEMP, fluid resistivity (FR) and flowmeter (FM); Dynamic logs: TEMP, FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

9. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

10. Back-plug the pilot hole with cement to the base of the 50-inch OD surface carbon steel casing.

11. Ream the pilot hole to a nominal 50-inch diameter borehole to approximately 1,180 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

12. Conduct geophysical logging (CAL and NGR) in the reamed hole in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

13. Install the 40-inch OD intermediate carbon steel casing to approximately 1,175 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

14. Drill out cement plug and drill a pilot hole centered at the bottom of the 40-inch OD intermediate carbon steel casing with a 12.25-inch bit to approximately 3,100 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

15. During drilling of the pilot hole collect up to four (4) cores at depths selected in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

16. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

17. Conduct up to four (4) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

18. Back-plug the pilot hole with cement to the base of the 40-inch OD intermediate carbon steel casing.

19. Ream the pilot hole to a nominal 40-inch diameter borehole to approximately 2,975 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

20. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

21. Install the 30-inch OD intermediate carbon steel casing to approximately 2,970 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

22. Drill out cement plug and drill a pilot hole centered at the bottom of the 30-inch OD intermediate carbon steel casing with a 12.25-inch bit to 5,250 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock formation, and water quality samples in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

23. During drilling of the pilot hole collect up to eight (8) cores at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

24. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

25. Conduct up to four (4) packer tests at depths in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

26. Install drillable bridge plug at a depth of ±4,070 feet bls.

27. Back-plug the pilot hole with cement to the base of the 30-inch OD intermediate carbon steel casing.

28. Ream the pilot hole to a nominal 30-inch diameter borehole to approximately 4,065 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

29. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

30. Install the 20-inch OD final seamless steel casing to approximately 4,060 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1.**

31. Cement the 20-inch OD final seamless steel casing from the bottom of the casing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**. Logging may be waived if poor fill-up is encountered.

32. Conduct a standard cement bond log following completion of cementing of the 20-inch OD final seamless steel casing to within 300 feet of land surface in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

33. Cement the final ±300 feet of the 20-inch OD final seamless steel casing.

34. Conduct casing pressure test of the 20-inch OD final seamless steel casing in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

35. Drill out cement plug at the base the 20-inch OD final seamless steel casing and ream the pilot hole to a nominal 16-inch diameter borehole to approximately 5,250 feet bls using the reverse-air circulation method. Record mechanical deviation surveys at intervals in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**.

36. Conduct geophysical logging (CAL, NGR, TV) in accordance to **Exhibit 18A - Summary of Testing for Exploratory Well IW-1**.

37. Install the 10.72-inch ID Red Box 1250 FRP tubing (or approved equal) and cementing packer to approximately 4,050 feet bls with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11A** – **Summary of Testing for Exploratory Well IW-1**.

38. Cement the 10.72-inch ID Red Box 1250 FRP injection tubing from the bottom of the tubing to ± 300 feet bls. After each cement stage, perform static TEMP and NGR logs to confirm the top of cement in conjunction with measurement from tremie pipe hard tags in accordance with **Exhibit 11A - Summary of Testing for Exploratory Well IW-1**. Logging may be waived if poor fill-up is encountered.

39. Conduct a standard cement bond log following completion of cementing of the 10.72-inch ID Red Box 1250 FRP injection tubing to within 300 feet of land surface in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1.**

40. Cement the final ±300 feet of the 10.72-inch ID Red Box 1250 FRP injection tubing.

41. Conduct casing pressure test the 10.72-inch ID Red Box 1250 FRP injection tubing in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

42. Develop the well (injection zone). Dispose of produced settled water in the discharge location at the Facilities approved by the engineer of record (EOR). Purge well in accordance with FDEP SOP protocol.

43. In accordance with FDEP SOP protocol, upon completion of development, collect background groundwater samples from the injection zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards (Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only for the background groundwater samples) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

44. Complete installation of wellhead fittings and valves in accordance with **Exhibit 6 – Exploratory Well IW-1 and Dual-Zone Monitor Well Wellhead Completion Details**.

45. Prepare for remaining mechanical integrity testing and furnish and install temporary piping, pumps, and valves to deliver clean and clear water for conducting a color video survey for the final inspection of the 10.72-inch ID Red Box 1250 FRP injection tubing and open hole in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

46. An injection test shall be conducted upon re-classifying the well for operation as a Class I Industrial Injection Well. Once re-classified, FDEP will be notified of injection testing and conducting external mechanical integrity testing with geophysical logging (NGR, high-resolution temperature [HRT] log and a radioactive tracer survey [RTS]) in accordance with **Exhibit 11A – Summary of Testing for Exploratory Well IW-1**.

47. Install temporary barriers and final concrete pad. Plug and abandon temporary shallow monitoring wells.

48. Clean and restore disturbed areas around the drilling site.

The following provides a chronological description of the construction, well drilling, and testing activities associated with the construction of Well DZMW-1, which may be started after Class V Exploratory Well IW-1 reaches the proposed LMZ depth for Well DZMW-1 and all the necessary information has been collected and evaluated to define the UMZ, USDW and LMZ at the site. **Exhibit 11B** provides a Summary of Testing to be conducted during construction activities. The final design of Well DZMW-1 will be contingent upon the results of Well IW-1 drilling and testing.

1. Drill a pilot hole to confirm the base of the surficial aquifer. The casing seat depth of the 34-inch OD (wall thickness to be determined) pit carbon steel casing will terminate in the confining unit (Intermediate Confining Unit) for isolation of the Surficial Aquifer and stabilize shallow unconsolidated sediments for drilling operations. The casing seat depth will be determined by the Contractor and reviewed and approved by the Project Geologist/Engineer prior to its installation. Excavate fill materials and install a 34-inch OD (wall thickness to be determined) pit carbon steel casing to the depth required for the drilling system; the Project Geologist/Engineer will oversee the installation of the pit casing. The final floor elevation within the pit casing will accommodate the installation of a rotating head or other sealing mechanisms to control fluids during drilling. Excavated materials shall be stockpiled onsite.

2. Construct a temporary fabricated steel (or equal) fluid containment pad.

3. Install four (4) 4-inch diameter PVC shallow PMWs at locations approved by the FDEP. PMW locations are shown in **Exhibit 2 Proposed Exploratory Well, Dual-Zone Monitoring Well and Pad Monitoring Well Locations** and PMW construction details are show in **Exhibit 5 – Pad Monitoring Well Design**. A NELAP certified laboratory will be utilized to conduct analyses on background samples collected at the PMWs.

4. Mobilize and set up drilling equipment at the MW site.

5. Drill a nominal 12.25-inch diameter pilot hole using standard mud-rotary drilling methods to approximately 550 feet bls, record mechanical deviation surveys and collect rock formation samples at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

6. Conduct geophysical logging in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** (CAL, NGR, SP, DIL, BHCS w/ VDL and ABI).

7. Ream pilot hole to nominal 34-inch diameter borehole using the direct mud-rotary method to approximately 505 feet bls and record mechanical deviation surveys at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

8. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

9. Install the 24-inch OD surface carbon steel casing (0.500-inch wall) to approximately 500 feet bls in accordance with **Exhibit 3 – Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**, and cement to surface. Conduct geophysical logging [Temperature (TEMP) and NGR] after each cement stage in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm top of cement in conjunction with measurement from tremie pipe hard tags.

10. Install the artesian flow control device, to control flow at the artesian head pressures within the Floridan Aquifer System during reverse-air circulation drilling.

11. Drill out cement plug and drill a nominal 12.25-inch diameter hole centered at the bottom of the 24-inch OD casing to approximately 2,200 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock/water formation samples, and analyze air-lifted water samples during reverse-air drilling in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

12. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

13. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Collect and analyze (NELAP-Certified laboratory) groundwater samples during packer testing to confirm the water quality of the UMZ.

14. Install drillable bridge plug at a depth of ±2,080 feet bls.

15. Back-plug the pilot hole with cement to the base of the 24-inch OD surface carbon steel casing.

16. Ream pilot hole to nominal 24-inch diameter borehole using the direct mud-rotary method to approximately 2,080 feet bls and record mechanical deviation surveys at intervals in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**.

17. Conduct geophysical logging (CAL and NGR) in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

18. Install the 16-inch OD final seamless steel casing to approximately 2,075 feet bls in accordance with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details** and cement to surface. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

19. Drill out cement plug and drill a nominal 12.25-inch diameter hole centered at the bottom of the 16-inch OD final seamless steel casing to approximately 3,070 feet bls using the reverse-air circulation method. Record mechanical deviation surveys, collect rock/water formation samples, and analyze air-lifted water samples during reverse-air drilling in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

20. Conduct geophysical logging (Static Logs: CAL, NGR, SP, DIL, BHCS w/ VDL, TV or OBI or ABI, TEMP, FR and FM; Dynamic logs: TEMP: FR and FM) on the pilot hole in accordance to **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

21. Conduct up to two (2) packer tests at depths in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Collect and analyze (NELAP-Certified laboratory) groundwater samples during packer testing to confirm the water quality of the LMZ.

22. Install the 6.21-inch ID Red Box 1250 FRP tubing (or approved equal) with attached external cementing packer to approximately 2,970 feet bls in accordance with **Exhibit 3** – **Exploratory Well IW-1 and Dual-Zone Monitor Well DZMW-1 Construction Details**. And conduct a standard cement bond log on the casing, before cementing, in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

23. Cement approximately 770 feet of the bottom 6.21-inch ID Red Box 1250 FRP tubing, from approximately 2,970 feet to 2,200 feet bls. After each cement stage, perform static TEMP and NGR logs in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1** to confirm the top of cement in conjunction with measurement from tremie pipe hard tags.

24. Conduct CBL once cementing is complete in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.**

25. Install temporary wellhead appurtenances, and after the cement has cured, perform casing pressure test on the 6.21-inch ID FRP tubing using an inflatable down-hole packer in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**

26. Develop both monitoring zones in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1**, following FDEP SOP protocol. Upon completion of development, collect a groundwater sample from each completed monitoring zone and submit them to a NELAP-Certified laboratory for analysis of Primary and Secondary Drinking Water Standards

(Note: asbestos, Dioxin, butachlor, acrylamide, and epichlorohydrine will be sampled for only for the background groundwater samples) and Industrial Wastewater Indicator Parameters for Groundwater Monitoring.

27. Perform final inspection of 6.21-inch ID FRP tubing by running a CAL log (open-hole only) and TV survey while flowing or pumping the 6.21-inch ID FRP tubing in accordance with **Exhibit 11B – Summary of Testing for Dual-Zone Monitor Well DZMW-1.** Discharge produced settled water to discharge location at the Facilities approved by the EOR.

28. Install temporary wellhead assembly and appurtenances in accordance with **Exhibit 5 – Temporary Wellhead Drawings**.

29. Install temporary pressure transducer in each monitoring zone (UMZ and LMZ) for measurement of artesian head (elevation) during pre-injection test background period, injection testing, and recovery periods (pending FDEP approval).

5. Abandonment plan.

This Plugging and Abandonment (P&A) plan outlines the procedures and estimated cost for P&A for Well IW-1, which is proposed to be converted into Injection Well IW-1, and for Well DZMW-1 located at the Facilities. Well IW-1 will have an approximate depth of 5,250 feet bls, while Well DZMW-1 will have an approximate depth of 3,070 feet bls. If the injection well system is abandoned, the injection zone and monitoring zones must be effectively plugged and sealed to prevent the upward migration of fluid from the injection zone and/or an interchange of formation water between aquifers. The P&A opinion of estimated costs is provided in **Exhibit 12A,** and the Abandonment Details are provided in **Exhibit 12B**.

This P&A plan describes the procedure for plugging and sealing Well IW-1 and both monitoring zones of Well DZMW-1 using gravel and cement. Gravel will be used to fill in the injection zone up to 10 feet below the base of the FRP tubing. The 10.72-inch ID FRP injection tubing will then be plugged with cement from above the gravel top to land surface. For Well DZMW-1, each monitoring zone will be filled with gravel in the open borehole intervals up to 10 feet below the base of each casing and each respective casing will be cemented to land surface.

The following is a sequence of gravel and cement sealing of the Well IW-1 injection zone and of the Well DZMW-1 monitoring zones. The cost calculations allow for the purchase of all the materials and services necessary for well abandonment tasks and represent the approximate cost for P&A of the Wells IW and DZMW, including a 10% contingency and estimated associated oversight for engineering costs of 20%.

As presented in **Exhibit 12B**, the materials, quantities and services provided to plug the IW will proceed as follows:

1. Mobilize drill rig, kill the well by filling the cemented 10.72-inch ID FRP injection tubing with weighted drilling mud or salt, and remove the valve assembly and appurtenances from the wellhead. Conduct geophysical logging.

2. Add a volume of crushed limestone gravel to the well equal to the volume of the open hole section of Well IW-1 to fill the open formation to approximately 10 feet below the bottom of the 10.72-inch ID FRP injection tubing. Verify the depth to the top of the gravel by tagging with a wireline. Place neat cement in stages into the 10.72-inch ID FRP injection tubing through a tremie pipe to the top of the gravel. The quantity of cement pumped above the top of the gravel should be

equivalent to the volume of cement required to fill approximately 10 feet of open hole and the entire length of 10.72-inch ID FRP injection tubing.

3. The cement should be allowed to set for 12 to 24 hours and then hard tagged with a wireline or tremie pipe to determine if sufficient fill up has been achieved.

4. The remainder of the 10.72-inch ID FRP injection tubing can then be filled with neat cement using the tremie method to land surface.

The UMZ and LMZ of the Well DZMW-1 will be plugged by filling the open-hole portion of each zone with gravel up to 10 feet below the base of the respective casing and pumping cement to fill each respective casing to land surface in stages. The LMZ will be abandoned first followed by the UMZ. As presented in **Exhibit 12B**, the proposed plan to abandon the Well DZMW lower and upper zones by gravel and cement method will proceed as follows:

1. Mobilize a drill rig and kill the well by partially filling the 6.21-inch ID FRP tubing of the LMZ with weighted drilling mud or salt. Remove the wellhead flanges and appurtenances from the well. Conduct geophysical logging.

2. Add a volume of gravel to the well equal to the volume of the open-hole sections of the monitoring zones. Fill the open-hole with gravel to approximately 10 feet below the bottom of each casing (to 2,980 feet bls within the 6.21-inch ID FRP tubing and to 2,085 feet bls within the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD final seamless steel casing). Verify the depth to gravel placement by hard tagging the gravel top in both zones with a wireline or tremie pipe.

3. For the LMZ, pump neat cement on top of the gravel placed in the 6.21-inch ID FRP tubing. For the UMZ, pump neat cement on top of the gravel through a tremie pipe placed in the annulus between the 6.21-inch ID FRP tubing and the 16-inch OD final seamless steel casing. Fill the casings with the neat cement in stages to land surface.

4. Verify the depth of each stage by hard tagging the cement top with a wire line or tremie pipe.

5. Complete below ground and add monument.

3.0 Supplemental Information - Future Class I Industrial Injection Well Permit Application

(Responses to Part A, Numbers 1-5 of Form 62-528.900(1))

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. **A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.**

This information was provided in Item No. 2 Part (F) of Form 62-528.900(1). Also, please see **Exhibits 7A, 7B, 9, and 10A-10H** for associated AOR information.

2. **A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.**

This information was provided in Item No. 2 Part (F) of Form 62-528.900(1). Also, please see **Exhibit 9** Tabulation of wells and well permits found within the 1-Mile Area of Review.

3. **Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.**

The different terminology for the hydrogeologic units of the Floridan Aquifer System (FAS) over different studies is presented in **Exhibit 13** (Williams and Kuniansky, 2016). A stratigraphic column showing the relation of hydrogeologic units of the FAS to geologic units and their lithology based on the hydrogeologic framework report *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida* is presented in **Exhibit 14A** (Reese, R. S. and Richardson E., 2008). **Exhibit 14B** provides a regional stratigraphic column of the Paleogene through the Upper Jurassic aged geologic formations of the South Florida Basin (Roberts-Ashby et al., 2013).

Near the Facilities, underground sources of drinking water are present in the upper FAS and potentially in the lower FAS. A potentiometric map of the UFA is presented in **Exhibit 15A,** showing groundwater flow is toward the coast (West). The elevation of the top of the FAS is highly variable onsite and ranges from approximately -50 feet NGVD29 as depicted on **Exhibit 15B.** The elevation of the top of the LFA is at approximately -1,475 feet NGVD29 as shown in **Exhibit 15D.** **Exhibit 15E** shows the elevation of the base of the FAS, which is approximately -3,100 feet NGVD29. A map of water quality zone contours indicating

the elevation of the 10,000-mg/L TDS isopleth (USDW) throughout Florida is presented in **Exhibit 15F**, indicating its presence at approximately 2,600 feet NGVD29 below the Facilities. This map also shows that the Facilities are in a potential salinity inversion area, meaning fresher water could lie beneath more saline water. The estimate of the base of the USDW from **Exhibit 15F** is approximately 260 feet shallower than the anticipated base of the USDW discussed in Section 2, Item No. 1. Based on the local and regional hydrostratigraphic cross sections utilizing nearby wells presented in Exhibits **16B**, **16C** and **16D,** the base of the USDW is anticipated to be at 2,860 feet bls below the Facilities. An isopach map displaying the thickness of freshwater in the FAS is shown in **Exhibit 15G**, which shows the Facility lie above freshwater saturated zone that is approximately 2,600 feet thick.

An elevation map of the Oldsmar Formation Permeable Zone including the geographical extent of the higher-permeability unit called the Boulder Zone is presented in **Exhibit 15H**. This figure shows the Boulder Zone is not present and that the estimated TDS concentration is less than 10,000 mg/L in the region of western Polk County, meaning, a USDW could be present in the Oldsmar Formation Permeable Zone below the Facilities. The thickness of the Middle Cedar Keys Formation which serves as a confining unit (Sub-Floridan Confining Unit [SFCU]) below the LFA is presented in **Exhibit 15I**. A map displaying the thickness of the Lower Cedar Keys and Upper Lawson Limestone Formations, a portion of the proposed injection zone (UCPZ), is provided in **Exhibit 15J**. These two maps were obtained from a regional investigation of using the Lower Cedar Keys and Upper Lawson Limestone Formations as an injection zone for carbon sequestration (Roberts-Ashby et al., 2013).

The potentiometric surface of deeper hydraulically isolated zones below the FAS, particularly the Upper Cretaceous Permeable Zone, have not been extensively mapped like the UFA. The potentiometric surface of the Upper Cretaceous Permeable Zone may be influenced by the operation of existing IWs used to dispose of municipal or industrial effluent, such as those at the Tampa Electric Company (TECO) Polk Power Plant approximately 11 miles south of the Facilities. Since no operational injection wells have been constructed or operated within the AOR for this project, the presence of effluent/concentrate in the proposed injection zone or confining units is not expected at the Facilities.

Local hydrostratigraphic cross sections A-A’, B-B’ and C-C’ are presented in **Exhibits 16B, 16C and 16D**. The depths of nearby USDWs (defined by the 10,000 mg/L-isopleth) were gathered from construction and testing reports of nearby wells and are indicated in **Exhibits 16B, 16C and 16D.** Using this information, the anticipated depth of the USDW at the Facilities is expected to be approximately 2,860 feet bls. Regional cross section P-P’ published in a revised hydrogeologic framework of the FAS report prepared by the USGS is presented in **Exhibit 17B** (Williams and Kuniansky, 2016). The depths of USDWs in the nearby wells used for the study are included in these figures.

The base of the USDW is expected to be approximately 788 feet below the base of the Middle Confining Unit II (MCU II) and is expected to lie approximately 60 feet above the top of the SFCU. The MCU II is expected to be approximately 945 feet thick and the SFCU is expected to be approximately 1,065 feet thick below the Facilities. The top of the injection zone, the UCPZ, is expected to be encountered approximately 1,125 feet below the base of the USDW. These estimated depths and thicknesses are based on the hydrogeological investigation performed during the creation of local hydrostratigraphic cross sections, discussed further in Item No. 4 below.

The open hole is designed to a depth of 5,250 ft bls, with the injection zone interpretted to be in the UCPZ of the Cedar Keys Formation and the underlying Lawson Limestone. Should test results indicate that the strata above 3,000 ft bls and below the base of the USDW has adequate transmissivity and sufficient

confinement between the USDW and the proposed injection zone, Mosaic will confer with FDEP about potential changes to the injection zone.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

Review of published literature revealed no confirmed geologic, tectonic, or physiographic structures, such as faults, folds, or penetrating sinkholes at the Facilities. A geological structure map of Florida is presented in **Exhibit 18**. Regional information on the geologic setting is presented below in Item No. 5.

Two north-south trending local cross sections, A-A' and C-C', and one east-west trending cross section, B-B', are presented in **Exhibits 16B, 16 C and 16D**. A location map for these hydrostratigraphic cross-sections utilizing available data from deep wells within Hillsborough, Polk, Pasco, Sumter, Lake, Manatee, Pinellas and Hardee Counties, is presented in **Exhibit 16A**. These cross-sections were developed using available data from the FDEP Geospatial Open Data Portal, the FDEP Oculus Electronic Management System, and the South Florida Water Management District's (SFWMD) DBHydro environmental database. Delineation of the hydrostratigraphic boundaries were established primarily from the construction and testing reports of nearby wells as well as interpretation of geophysical logs and lithologic data. The depths of USDWs in these nearby wells are also included in these figures. The position of the proposed Facilities IW System site is shown for reference on the cross-sections which show the general structure of the geologic units extending from land surface through the lower Cretaceous formations. Hydrostratigraphic boundaries for the following units are depicted:

- Surficial Aquifer System (SAS)
- Intermediate Confining Unit (ICU)
- Upper Floridan Aquifer (UFA)
- Middle Semi-Confining Unit I (MCU I)
- Avon Park Permeable Zone (APPZ)
- Middle Semi-Confining Unit II (MCU II)
- Lower Floridan Aquifer (LFA)
- Sub-Floridan Confining Unit (SFCU)
- Upper Cretaceous Permeable Zone (UCPZ)
- Semi-Confinement

The uppermost aquifer system is the SAS and is composed of unconsolidated sands, clay, marl, shells, limestone, and sandy clay. In some areas of Central-West Florida, the SAS is not present because the FAS is exposed at the surface due to karst topographic features (Crandall, 2007). In Polk County, the SAS has a thickness of approximately 85 feet. The SAS is underlain by low-permeability sediments of the Hawthorn Group from the Miocene Epoch. The Hawthorn Group contains sands, clays, limestones and varying amounts of phosphate and dolomite content. The Hawthorn group serves as a confining bed referred to as the ICU and these sediments are approximately 175 feet thick at the proposed Exploratory Well IW-1 location.

The top of the UFA of the FAS is encountered at the base of the ICU which coincides with either the limestones of the lower Arcadia Formation or the upper Suwannee Limestone at a depth of approximately 260 feet bls at the proposed Exploratory Well IW-1 location. A structure map showing the elevation of the

top of the UFA throughout Florida is presented in **Exhibit 15B**. Researchers (Miller 1986; Reese, 1994) have described multiple discrete confining units separating the individual aquifers of the FAS. The Ocala Limestone and upper portion of the Avon Park Formation are typically composed of semi-low-permeability limestones and dolostones and serve as a semi-confining unit referred to as the MCU I (sometimes called the Ocala-Avon Park Lower Permeability Zone or OCAPLPZ) that separates the UFA from the APPZ. The extent of the MCU I is believed to "pinch out" or be very thin in much of Central-West Florida and therefore this unit, if present, is considered leaky at the Facilities (Williams and Kuniansky, 2016). The presence of this zone will be confirmed during drilling of the exploratory well. The APPZ is a higher permeable zone of the Avon Park Formation and is sometimes considered part of the UFA (Reese and Richardson, 2008) or part of the LFA. Some researchers even refer to it as the "Middle Floridan Aquifer," but is considered part of the UFA in this report. The entire UFA including the MCU I and APPZ is approximately 870 feet thick at the Facilities.

Below the UFA is an evaporite-bearing confining unit generally considered not leaky in Central-West Florida, called the MCU II (Miller, 1986). The MCU II is sometimes referred to as the Middle Avon Park Composite Unit (Williams and Kuniansky, 2016) and contains lower permeability deposits such as gypsiferous dolostone, gypsum, anhydrite, limestone, and organic-rich clays in the middle and lower portions of the Avon Park Formation. The MCU II separates the UFA from the LFA. Beneath the Facilities, the MCU II is expected to be approximately 945 feet thick, though could be interbedded with small permeable zones. **Exhibit 15C** presents a structure map showing the elevation to the top of the MCU II and its general composition across Florida. **Exhibit 15D** presents a structure map showing the elevation to the top of the LFA. The LFA is comprised of the Lower Avon Park Formation, the Oldsmar Formation, and the Upper Cedar Keys Formation and contains all permeable zones below the MCU II, including a Lower Avon Park Permeable Zone and the Oldsmar Formation Permeable Zone (Williams and Kuniansky, 2016). The elevation of the top of the Oldsmar Formation Permeable Zone is presented in **Exhibit 15H,** which shows the water quality of this unit below the Facilities could represent a USDW (TDS concentrations below 10,000 mg/L). This figure also shows that the higher permeable zone (Boulder Zone) of the Oldsmar Permeable Zone that others use as an injection zone for Class I Injection Wells in South Florida. The Boulder Zone is not present below the site. The LFA is expected to be approximately 850 feet thick under the Facilities.

The Cedar Keys Formation in West-Central Florida is typically classified into three units (upper, middle, and lower). The upper unit is typically considered part of the LFA. The middle unit is anhydrite-rich, low in permeability and typically considered the primary confining unit (serving as the SFCU in this case) in between the FAS and the UCPZ. The Lower Cedar Keys Formation and the Lawson Limestone are permeable and serve as the UCPZ. The UCPZ has been researched for its storage potential as an injection zone for injection wells, both Class I and Class VI Carbon Sequestration Wells (Roberts-Ashby et al., 2013). A map displaying the thickness of the Middle Cedar Keys Formation (that serves as the SFCU) is presented in **Exhibit 15I**. The SFCU is expected to be approximately 1,065 feet thick below the Facilities based on the hydrostratigraphic projections from nearby wells and interpreted while creating the local cross sections provided in **Exhibits 16B** and **16C**. The upper member of the Lawson Limestone is mostly an algal and rudistid biostrome that has undergone extensive alteration of the primary and is somewhat high in permeability (Applin and Applin 1944, 1967; Miller 1986; Roberts-Ashby et al., 2013) and the lower member is composed of chalk with thin lenses of dolostone and is lower in permeability (Roberts-Ashby et al., 2013). A map displaying the thickness of the Lower Cedar Keys Formation and the Upper Lawson Limestone (referred to as the Cedar Keys/Lawson Limestone injection zone [CKLIZ] in the figure) is presented in **Exhibit 15J**. These two formations have also been considered as a potential injection zone for carbon capture and sequestration (CCS), based on research by Roberts-Ashby et al., 2013, and do not

include the Lower Lawson Limestone unit. This storage complex is depicted on the stratigraphic column provided in **Exhibit 14B**. The Lower Lawson Limestone is believed to be permeable enough to receive wastewater and is thus included in the LCPZ in the region of West-Central Florida according to the TECO IW-2 Well Completion Report (MWH, 2013). The UCPZ is expected to be approximately 965 feet thick below the Facilities.

5. Generalized maps and cross sections illustrating the regional geologic setting.

One regional cross section created during a regional USGS study *Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina* (Williams and Kuniansky, 2016) is presented in **Exhibit 17B**. These include one east-west trending (P-P’), in the region of the Facilities. A location map for the wells used in these hydrostratigraphic cross sections is presented in **Exhibit 17A**. The depths of USDWs in nearby wells are also included in this figure. Hydrostratigraphic and lithologic boundaries are presented in these cross sections. All the regional-scale maps referred to in the above Item No. 4 are also relevant to Item No. 5.

The Facilities are located within the Atlantic Coastal Plain physiographic region. The region’s geologic and tectonic setting is the product of a complex history of continental collisions and rifting followed by deposition of sediments on the Florida platform. Basement rocks consist of Paleozoic and Mesozoic aged igneous, metamorphic, and sedimentary rocks. The overlying Mesozoic Era carbonate and evaporite sedimentary rocks may be 15,000 feet thick (Miller, 1986). Overlying the Mesozoic Era rocks, approximately 6,000 feet of Cenozoic Era carbonate and siliciclastic sedimentary rocks occur (Applin and Applin, 1944, Arthur, J.D., 1988; Milton, C., 1972). The geologic structures as shown in **Exhibit 18** that have affected shallow Tertiary and Quaternary Period sediments of the Florida Platform have been defined by numerous authors (Puri and Vernon, 1974; Miller, 1986; Scott, 1988; Scott, 1992). Most of the structures recognized as influencing the deposition, erosion and alteration of the Cenozoic Era sediments in Florida do not appear to have had a significant effect on the surface expression of the lithostratigraphic units (Scott, 1988).

As previously mentioned, local hydrogeologic cross-sections for west-central Florida are shown in **Exhibits 16B, 16C and 16D. Exhibit 14B** provides a generalized stratigraphic column of the geologic formations below the region of the Facilities obtained from a regional-scale investigation of using the Upper Cretaceous units in Florida as an injection zone for carbon sequestration (Roberts-Ashby et al., 2013). A geologic map of the Northern Florida Peninsula is presented in **Exhibit 19A and 19B**. The position of the proposed Facilities IW System site is shown for reference on the cross-sections which show the general structure of the geologic units extending from land surface through the lower Eocene formations.

4.0 References

Applin, P.L. and Applin, E.R, *Regional Subsurface Stratigraphy and Structure of Florida and Southern Georgia*, AAPG Bulletin, Volume 28, Issue 12, December 1944.

ArcGIS, NAVD88 Ground Surface Elevations (ft)
https://www.arcgis.com/home/webmap/viewer.html?layers=ca44a6a0714d4d3daa43eba592e8b11b

ASRUS and Reiss Engineering, 2014, *Engineering Report for the Construction and Testing of the Polk County Northwest Regional Wastewater Treatment Facility ASR Well System*, August 2014.

Arthur, J.D., *Petrogenesis of Early Mesozoic Tholeiite in the Florida Basement and an Overview of Florida Basement Geology*, Report of Investigations no. 97, Florida Geological Survey, 1988;

Crandall, C., 2007, Hydrogeologic settings and ground-water flow simulation of the Northern Tampa Bay Regional Study Area, Florida, section 5 of Paschke, S.S., ed., Hydrogeologic settings and ground-water flow simulations for regional studies of the transport of anthropogenic and natural contaminants to public-supply wells—studies begun in 2001: Reston, Va., U.S. Geological Survey Professional Paper 1737–A, pp. 5–1 – 5–30.Dallmeyer, R.D., A *Tectonic Linkage between the Rodelide Orogen (Sierra Leone) and the St. Lucie Metamorphic Complex in the Florida Subsurface*, The Journal of Geology, v. 97, no. 2, March 1989.

Florida Department of Environmental Protection (1990, January 1). *Underground Injection Control Monitoring Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved December 6, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-monitoring-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (2009, March 1). *Underground Injection Control (UIC) Class V ASR Wells*. Florida Department of Environmental Protection Geospatial Open Data. Retrieved December 6, 2023, from https://maps-fdep.opendata.arcgis.com/datasets/underground-injection-control-uic-class-v-asr-wells/explore?location=27.891589%2C-83.466600%2C5.97

Florida Department of Environmental Protection (2018, February 22). *Subsidence Incident Reports Map.* Florida Department of Environmental Protection Geospatial Open Data. Retrieved December 6, 2023, from Subsidence Incident Reports | Florida Department of Environmental Protection

Kinnaman, S.L., and Dixon, J.F., 2011, Potentiometric surface of the Upper Floridan aquifer in Florida and parts of Georgia, South Carolina, and Alabama, May – June 2010: U.S. Geological Survey Scientific Investigations Map 3182, 1 sheet.

Southwest Florida Water Management District (2022, May 5). *Well Construction Permit Locations.* Retrieved December 6, 2023 from Well Construction shapefile - Overview (arcgis.com)

South Florida Water Management District Open Data. (n.d.). https://geo-sfwmd.hub.arcgis.com/

DBHYDRO Wells and Boreholes. (n.d.). https://geo-sfwmd.hub.arcgis.com/datasets/dbhydro-wells-and-boreholes/explore

FGS Geologic Data | Florida Department of Environmental Protection. (n.d.). https://floridadep.gov/fgs/data-maps/content/fgs-geologic-data

Water Resources of the United States—National Water Information System (NWIS) Mapper. (n.d.). https://maps.waterdata.usgs.gov/mapper/index.html

Miller, J. A., 1986, *Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina*, U.S. Geological Survey Professional Paper 1403B.

Milton, C., Igneous and Metamorphic Basement Rocks of Florida, Bulletin 55, Florida Bureau of Geology, 1972.

MWH, 2013, *Well Completion Report for Polk Power Station Injection Well IW-2 and Dual Zone Monitor Well DZMW-2*

Puri and Vernon, 1974; Geologic Framework of the High Transmissivity Zones in South Florida, Bureau of Geology, Special Publication No. 20, 101 p.

Reese, R. S. (1994). *Hydrogeology and the distribution and origin of salinity in the Floridan Aquifer System, Southeastern Florida*. Water-Resources Investigations Report. Retrieved March 6, 2023, from https://pubs.er.usgs.gov/publication/wri944010

Reese, R. S. and Richardson E., *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida, U.S. Geological Survey Scientific Investigations Report 2007-5207*, 2008.

Roberts-Ashby, T. L., Stewart, M. T., & Ashby, B. N. (2013, September). *An evaluation of porosity and potential use for carbon dioxide storage in the Upper Cretaceous Lawson Formation and Paleocene Cedar Keys Formation of south-central and southern Florida*. Pubs.geoscienceworld.org. https://pubs.geoscienceworld.org/eg/article-abstract/20/3/109/138140/An-evaluation-of-porosity-and-potential-use-for-Formation of south-
central and southern Florida, Environmental Geosciences, V. 20, No. 3 (September 2013), pp. 109-135

Scott, T.M., 1988. *The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Florida Geological Survey*, Bulletin 59, 148 p

Scott, 1992, *A Geological Overview of Florida,* Florida Geological Survey, Open File Report No. 50, 81 p.

Williams, L.J., and Kuniansky, E.L., 2016, *Revised hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama, and South Carolina* (ver. 1.1, March 2016): U.S. Geological Survey Professional Paper 1807, 140 p., 23 pls., http://dx.doi.org/10.3133/pp1807.

WSP, 2020, *Polk Regional Water Cooperative Combined Projects Implementation Phase I, Technical Memorandum West Polk LFA Water Production Facility Test Well Completion Report*, June 2020.

FLORIDA DEPARTMENT OF
Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Alexis A. Lambert
Secretary

Sent Via Electronic Mail November 22, 2024

In the Matter of an Application for Permit by:

Scott Wuitschick
Geotechnical Director
Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Florida 33547
Scott.Wuitschick@MosaicCo.com

UIC Permit File:	0441607-001-UC/1EX
WACS Facility ID:	108119
County:	Hillsborough
Class:	Class V Exploratory Well System
Well:	IW-1
Permit Type:	Construction
Facility:	Mosaic Class V Exploratory Well

Notice of Draft Permit

The Department of Environmental Protection (Department) hereby gives notice that a draft permit has been developed for the proposed project as detailed in the application specified above, for the reasons stated below.

The applicant, Mosaic Fertilizer, LLC, Scott Wuitschick, Geotechnical Director, 13830 Circa Crossing Drive, Lithia, Florida 33547, applied on October 27, 2023, for a Class V exploratory well construction permit.

The Department has permitting jurisdiction under Chapter 403 of the Florida Statutes (F.S.) and the rules adopted thereunder. The project is not exempt from permitting procedures. The Department has determined that an Underground Injection Control permit is required for the proposed work.

Pursuant to Section 403.815, F.S., and Rule 62-528.315(6)(b) of the Florida Administrative Code, the applicant is required to publish at their own expense the enclosed Notice of Draft Permit. The notice must be published one time only within 30 days in a newspaper of general circulation in the area affected. For the purpose of this rule, "publication in a newspaper of general circulation in the area affected" means publication in a newspaper meeting the requirements of Sections 50.011 and 50.031, F.S., in the county where the activity is to take place. The applicant shall provide proof of publication to the Aquifer Protection Program of the Department within seven (7) days of publication. Failure to publish the notice and provide proof of publication within the allotted time may result in the denial of the permit.

Any interested person may submit written comments on the draft permit within 30 days of the public notice. Written comments may be submitted to the Department of Environmental Protection, Aquifer Protection Program, 2600 Blair Stone Road, MS 3530, Tallahassee, Florida 32399-2400. All comments received within the 30-day period and during the public meeting will be considered by the Department in formulating a final decision concerning this project. If a public meeting is arranged, it must be held in the area of the well no less than 30 days after publication of this notice for the purpose of receiving verbal and written comment concerning this project. If a public meeting is not arranged prior to publication, the notice must provide an opportunity for a public meeting. If a public

meeting is later scheduled, there will be another 30-day notice period for that meeting. Please contact Walsta Jean-Baptiste, at 850-245-8386 for additional information.

Executing and Clerking:
Executed in Tallahassee, Florida
State of Florida Department of Environmental Protection

Richard Lobinske

Richard Lobinske, Ph.D.
Environmental Administrator
Underground Injection Control
Aquifer Protection Program
Division of Water Resource Management

Certificate of Service

The undersigned duly designated clerk hereby certifies that this Notice of Draft Permit and all copies were sent on the filing date November 22, 2024, to the following listed persons:

Richard Lobinske, DEP/TLH, Richard.Lobinske@FloridaDEP.gov
Annette Solveigh, DEP/TLH, Annette.Solveigh@FloridaDEP.gov
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Jason Meadows, USEPA/ATL, Meadows.JasonB@EPA.gov

Filing and Acknowledgment

Filed, on this date, pursuant to Section 120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

Marjane C. Taylor
Digitally signed by Marjane C. Taylor
Date: 2024.11.22 16:07:28 -05'00'

Clerk

11/22/2024
Date

State of Florida
Department of Environmental Protection

Notice of Draft Permit

The Department of Environmental Protection hereby provides notice that it has prepared a draft permit for the proposed project as detailed in the application, subject to the conditions specified in the draft permit and summarized below. The applicant, Mosaic Fertilizer, LLC, Scott Wuitschick, Geotechnical Director, 13830 Circa Crossing Drive, Lithia, Florida 33547 applied on Oct 27, 2023, for a Class V exploratory well construction permit. The project is located at Mosaic Class V Exploratory Well, 10609 Paul S Buchman Hwy, Plant City, Florida 33565, in Hillsborough County (File 0441607-001-UC/1EX, WACS ID 108119).

The permittee will construct one non-hazardous Class V Group 9 exploratory well (IW-1) and associated dual-zone monitor well (DZMW-1) at the Mosaic Fertilizer, LLC, Plant City Concentrate Facility. No injection is authorized by this permit with the exception of a short-term injection test to test the suitability of the proposed injection zone.

The permittee will later apply for well reclassification as a non-hazardous Class I injection well for the disposal of non-hazardous phosphogypsum stack system (gyp-stack) industrial wastewater stored in the Mosaic Plant City Concentrate Facility, the phreatic water collected by the gyp-stack underdrain system, and recovery well water from the Mosaic Plant City Concentrate Facility. Injectate will be limited to wastewater generated and treated at the Mosaic Plant City facility and regulated under its National Pollutant Discharge Elimination System Permit (FL0000078).

The primary proposed location for IW-1 is latitude 28° 08' 51.25" N and longitude 82° 08' 19.08" W and the secondary location is latitude 28° 09' 44.87" N and longitude 82° 08' 29.90" W.

IW-1 is proposed to be constructed with a 20-inch diameter casing set to 3,610 feet below land surface (bls), a 10.72-inch diameter tubing set to 3,600 feet bls with a cemented annulus, and total depth of 5,100 feet bls.

The Department has permitting jurisdiction under Chapter 403 of the Florida Statutes and the rules adopted thereunder. The project is not exempt from permitting procedures. The Department has determined that an Underground Injection Control permit is required for the proposed work.

Any interested person may submit written comments on the draft permit and may request a public meeting within 30 days after publication of this public notice. A request for a public meeting shall be submitted in writing and shall state the nature of the issues proposed to be raised in the meeting. If a public meeting is later scheduled, there will be another 30-day notice period for that meeting. Written comments or a public meeting request shall be submitted to the Department of Environmental Protection, Aquifer Protection Program, 2600 Blair Stone Road, MS 3530, Tallahassee, Florida 32399-2400, which is the office processing this permit application. All comments received within the 30-day period will be considered in formulation of the Department's final decision regarding permit issuance.

The files associated with this order are available for public inspection during normal business hours, 8 a.m. to 5 p.m., Monday through Friday, except state holidays, at the Department of Environmental Protection, Southwest District, and at the Department of Environmental Protection, Aquifer Protection Program office in Tallahassee. Any additional information concerning this project may be obtained by contacting Walsta Jean-Baptiste, at 850-245-8386.

Florida Department of
Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Alexis A. Lambert
Secretary

Underground Injection Control
Class V, Group 9, Exploratory Permit

Permittee	**Permit/Certification**	
Scott Wuitschick, Geotechnical Director	UIC Permit Number:	0441607-001-UC/1EX
Mosaic Fertilizer, LLC	WACS Facility ID:	108119
13830 Circa Crossing Drive	Date of Issuance:	Draft
Lithia, Florida 33547	Date of Expiration:	Draft
Scott.Wuitschick@MosaicCo.com	Permit Processor:	Walsta Jean-Baptiste

Facility	**Location**	
Mosaic Plant City Facility	County:	Hillsborough
10609 Paul S Buchman HWY	Latitude:	IW-1 Primary: 28° 08' 51.25" N
Plant City, Florida 33565		IW-1 Secondary: 28° 09' 43.02" N
	Longitude:	IW-1 Primary: 82° 08' 19.08" W
		IW-1 Secondary: 82° 08' 29.90" W

DRAFT

Project: Exploratory Well System IW-1

This permit is issued under the provisions of Chapter 403, Florida Statutes (F.S.), and the rules adopted thereunder, particularly Chapter 62-528, Florida Administrative Code (F.A.C.). The above-named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department of Environmental Protection (Department) and made a part hereof and specifically described as follows.

To Construct: One non-hazardous Class V, Group 9, exploratory well (IW-1) at the Mosaic Fertilizer, LLC, Plant City Concentrate Facility. No injection is authorized by this permit with the exception of a short-term injection test to test the suitability of the proposed injection zone.

The permittee will later apply for well reclassification as a non-hazardous Class I injection well for the disposal of non-hazardous phosphogypsum stack system (gyp-stack) industrial wastewater stored in the Mosaic Plant City Concentrate Facility, the phreatic water collected by the gyp-stack underdrain system, and recovery well water from the Mosaic Plant City Concentrate Facility. Injectate will be limited to wastewater generated and treated at the Mosaic Plant City facility and regulated under its National Pollutant Discharge Elimination System Permit (FL0000078).

The primary proposed location for IW-1 is latitude 28° 08' 51.25" N and longitude 82° 08' 19.08" W and the secondary location is latitude 28° 09' 44.87" N and longitude 82° 08' 29.90" W.

IW-1 is proposed to be constructed with a 20-inch diameter casing set to 3,610 feet below land surface (bls), an 11.75-inch diameter tubing set to 3,610 feet bls with a cemented annulus, and total depth of 8,000 feet bls.

In Accordance With: The Application to Construct DEP Form No. 62-528.900(1) received October 27, 2023, response to the Department's request for additional information dated January 16, 2024, application addendum dated May 29, 2024, revised application addendum dated July 2, 2024, and supporting information submitted to the Aquifer Protection Program (APP) Tallahassee office.

Location: Mosaic Plant City Facility, 10609 Paul S Buchman HWY, Plant City, Florida 33565, in Hillsborough County.

The exploratory and monitor wells, as designated below by well name and Water Assurance Compliance System (WACS) Testsite identification (ID), and construction details at this facility, are as follows:

Table 1
Exploratory Well

Well Name	WACS Testsite ID	Well Depth (Feet bls)	Casing Size (Inches)[a]	Casing Thickness (Inches)	Casing or Tubing Type	Casing Depth or Interval (Feet bls)
IW-1	14247	8,000	50	0.5	Steel	330
			40	0.5	Steel	1,100
			30	0.5	Steel	3,000
			20	0.5	Steel	3,610
			11.75	0.49	FRP[b]	3,600
					Open Hole	3,610 – 8,000

Exploratory Well Notes: IW-1 will be constructed with new, unused well materials and fully cemented to land surface. [a]All sizes are outside diameter or nominal size. [b]Fiberglass-reinforced plastic (FRP) Red Box® series 1250 tubing with 10.72-inch inside diameter.

Subject To: Specific Conditions I-VI and General Conditions 1-24.

Specific Conditions

I. General Requirements

1. This permit is for Mosaic Fertilizer, LLC to construct IW-1 at the Mosaic Plant City facility. The exploratory well permit does not allow injection of wastewater into the well. This permit does not authorize the construction or operational testing of any other wells. *[62-528.440(2)(a), F.A.C.]*

2. In the event a well must be plugged or abandoned, the permittee shall obtain approval from the Department as required by Chapter 62-528, Florida Administrative Code. When no longer used for their intended purpose, these wells

shall be properly plugged and abandoned. Within 180 days of well abandonment, the permittee shall submit to the Department the proposed plugging method, pursuant to Rule 62-528.460, F.A.C. *[62-528.435(6) and 62-528.460(1), F.A.C.]*

II. Site Requirements

1. A drilling pad shall be provided to collect spillage of contaminants and to support the heaviest load that will be encountered during drilling. *[62-528.410(9)(b), F.A.C.]*
2. No drilling operations shall begin without an approved disposal site for drilling fluids, cuttings, or waste. It shall be the permittee's responsibility to obtain the necessary approval(s) for disposal prior to the start of construction. A detailed disposal plan shall be submitted to the Department prior to the commencement of drilling activities for the exploratory well and monitor well. *[62-528.410(9)(a), F.A.C.]*
3. Specific drilling pad dimensions and design drawings for Department record shall be provided prior to commencing construction and shortly after selection of the drilling contractor. *[62-528.410(9)(b), F.A.C.]*
4. The water table monitor wells surrounding the well pads shall be sampled and analyzed prior to drilling the exploratory well or monitor well and then weekly thereafter. Sampling shall include specific conductance (µmhos/cm), pH (standard units), chloride (mg/L), temperature (C), and water level (feet or PSI). *[62-528.410(9)(b), F.A.C.]*
5. Hurricane Preparedness – Upon the issuance of a "Hurricane Watch" by the National Weather Service, the preparations to be made include but are not necessarily limited to the following:
    a. Secure all on-site salt and stockpiled additive materials to prevent surface and/or groundwater contamination.
    b. Properly secure drilling equipment and rig(s) to prevent damage to well(s) and on-site treatment process equipment.

    [62-528.307(1)(f), F.A.C.]

III. Construction and Testing Requirements

A. General

1. Any construction, modification, repair, or abandonment of a well shall be performed by a Florida licensed water well contractor, licensed under Chapter 62-532, F.A.C., to engage in the business of construction, modification, repair, or abandonment of a well. *[62-532.200, F.A.C.]*
2. Well construction shall follow the requirements of Rule 62-532.500 for Water Well Construction Standards. *[62-532.500, F.A.C.]*

3. The measurement points for drilling and logging operations shall be surveyed and referenced to the North American Vertical Datum of 1988 (NAVD 88) prior to the onset of drilling activities for the exploratory well or monitor well. *[62-160.240(3)(b)3., F.A.C.]*
4. Blow-out preventers or comparable flow control devices shall be installed on the exploratory well and monitor well prior to penetration of the Floridan aquifer system. *[62-528.410(9)(c), F.A.C.]*
5. The Department shall be notified 7 days prior to the mobilization of drilling operations to the site. *[62-528.430(1), F.A.C.]*
6. Waters spilled during construction or testing of the exploratory well system shall be contained and properly disposed. *[62-528.307(1)(e) and (f), and 62-528.410(9)(b), F.A.C.]*
7. If additives that were not approved in the permit application are used during grouting, for lost circulation, or for any other reason, information on their properties shall be submitted to the Department prior to their use for review and approval. *[62-528.410(5)(c), F.A.C.]*
8. No more than 6% bentonite gel shall be used to cement any casing or tubing unless advance approval is received from the Department due to conditions found during the drilling and logging of the well. *[62-528.410(5)(f) and 62-528.420(5)(c), F.A.C.]*

B. Evaluation and Testing

1. The construction, geophysical logging, and packer testing programs shall be implemented in accordance with this permit and as proposed in the following submittals:
   - October 27, 2023, Well Construction Application
   - January 16, 2024, Request for Additional Information (RAI)
   - May 29, 2024, Application Addendum
   - July 2, 2024, Revised Application Addendum
   - Other approved submittals received by the Department.

   [62.528.307(1)(b), F.A.C.]
2. Exact depths of casing seats and monitor intervals shall be determined based on field conditions and the results obtained during the construction and testing program and are subject to the conditions of this permit. The exploratory well will be constructed first followed by the monitor well. *[62-528.410(4)(c), F.A.C.]*
3. Interval or packer tests shall be conducted in both the exploratory well and the monitor wells to identify confinement and the base of the USDW.
   a. The program shall include the number of interval or packer tests identified in the permit application, at intervals which are to be field determined.

b. At least one interval or packer test shall be conducted in each proposed monitoring interval.
c. Interval or packer tests shall be conducted in the anticipated confining intervals, from the lowermost zone of the USDW to the top of the potential injection zone. Results from the interval or packer tests will contribute to the demonstration of confinement. To the extent feasible, the interval or packer tests shall be performed over intervals that are sufficiently narrow so as not to include high hydraulic conductivity beds.
d. Water samples shall be collected from each interval or packer test, and analyzed for total dissolved solids (TDS), chlorides, specific conductance, ammonia, total Kjeldahl nitrogen, and sulfate.

[62-528.405(1)(a) and (2)(a), and 62-528.420(6)(f), F.A.C.]

4. Department approval is required prior to the following stages of construction and testing:

   Exploratory Well:
   a. Selection of exploratory well location
   b. Intermediate (30-inch) casing seat in exploratory well
   c. Final (20-inch) casing seat in exploratory well
   d. Final seat for 11.75-inch injection tubing and packer in exploratory well
   e. Short-term injection test

   [62-528.410(4)(c) and 62-528.420(4)(c), F.A.C.]

5. The depth of the USDW and the background water quality of the monitor zones shall be determined during drilling and testing using the following information:
   a. Water samples from packer test data with analysis and interpretation.
   b. Geophysical logging upon reaching the total depth of the appropriate pilot hole interval including the following logs at a minimum: caliper, gamma ray, dual induction, and borehole compensated sonic. Other logs as identified in the permit application documents shall be run.

   [62-528.405(1)(a) and 62-528.405(3)(b), F.A.C.]

6. The upper monitor interval shall be established within the lowermost portion of the USDW unless it can be demonstrated that no zone is present that can produce adequate water for collection of representative groundwater samples. *[62-528.425(1)(g)4., F.A.C.]*

   The lower monitoring interval shall be positioned in a zone below the base of the USDW that can produce adequate water for collection of representative groundwater samples. *[62-528.425(1)(g)4., F.A.C.]*

7. The data and analysis supporting the selection of the monitoring intervals shall be submitted to the Department after the collection, interpretation, and analysis of all pertinent cores, geophysical logs, packer tests and analysis of fluid samples. The Department shall approve the final selection of the specific upper

and lower monitoring intervals prior to monitor well completion. *[62-528.420(4)(c), F.A.C.]*

8. To identify the upper and lower monitoring zones, the following information from the potential injection and monitor wells and all available on-site sources of data shall be analyzed, interpreted and submitted for Department review and approval:
   a. Borehole televiewer or downhole television survey.
   b. The characteristics of the transition zone (especially regarding TDS) in the vicinity of the base of the USDW.
   c. Packer test data including water quality (TDS, chlorides, sulfate, specific conductance, ammonia, and total Kjeldahl nitrogen, at a minimum).
   d. The specific capacity of the proposed upper and lower monitoring zones based on packer testing results.
   e. The identification of the base of the USDW.

   [62-528.420(4)(c), F.A.C.]

9. Confinement shall be demonstrated using at a minimum, directly measured lithologic properties, geophysical evidence, and tests performed while pumping the formation. *[62-528.405(2)(c), F.A.C.]*

10. Test results pertaining to formation testing shall include and/or specifically reference the following informational and quality control items:
    a. Information that documents the calibration of tools, including field checks prior to testing.
    b. The conditioning/development of the borehole prior to logging, including the techniques used and the time periods in which they were applied, and
    c. Pertaining to packer/pump testing - recording the pumping rate regularly throughout the test to account for possible variations in the pumping rate, and providing information regarding the detection of packer leaks, if any, during testing.

    [62-528.405(2) and (3), F.A.C.]

11. Representative samples of circulation fluid shall be collected when drilling with water, air, or reverse air during the drilling of the pilot holes of the exploratory well and the monitor well. Representative samples of circulation fluid shall be collected at a minimum of every 90 feet during drilling. The circulation fluid samples shall be analyzed for chloride and specific conductance at a minimum. *[62-528.405(1)(a), 62-528.420(6)(g), F.A.C.]*

12. If effluent is encountered or suspected during pilot hole drilling and testing, the Department shall be notified immediately by telephone and in writing and immediate appropriate precautionary measures shall be taken to prevent any upward fluid movement. *[62-528.440(2)(d), F.A.C.]*

C. Mechanical Integrity

1. Mechanical Integrity:
   a. Injection is prohibited until the permittee affirmatively demonstrates that the well has mechanical integrity, and a construction permit has been issued for a Class I injection well. Note that under this Class V exploratory well permit, injection of wastewater is not allowed even after demonstrating mechanical integrity.
   b. If the Department determines that the exploratory well lacks mechanical integrity, written notice shall be given to the permittee.

   [62-528.307(2)(f), F.A.C.]

2. Mechanical integrity of each potential injection well shall be determined pursuant to Rules 62-528.300(6)(b) and (c), F.A.C. For wells with a fluid-filled casing/tubing annulus, this includes both continuous annular monitoring and a pressure test of the casing/tubing annulus every 5 years. *[62-528.300(6)(b) and (c), F.A.C.]*

3. Verification of pressure gauge calibration must be provided to the Department representative at the time of the test and in the certified test report. *[62-528.300(6)(f), F.A.C.]*

4. The Department's Southwest District office must be notified a minimum of seven (7) calendar days prior to all testing for mechanical integrity on the exploratory well. Any change in the approved testing procedure must be approved by the Department before testing begins. All testing must be initiated during daylight hours, Monday through Friday other than State Holidays, unless approval has been given by the Department. An evaluation of test results must be submitted with all test data. *[62-528.300(6)(f), F.A.C.]*

D. Surface Equipment

1. The integrity of the monitoring zone sampling systems shall be maintained at all times. Sampling lines shall be clearly and unambiguously identified by monitoring zone at the point at which samples are drawn. All reasonable and prudent precautions shall be taken to ensure that samples are properly identified by monitor well name or zone and that samples obtained are representative of those zones. Sampling lines and equipment shall be kept free of contamination with independent discharges and no interconnections with any other lines. *[62-528.307(1)(f) and 62-528.307(2)(b), F.A.C.]*

2. The surface equipment and piping for the exploratory well and the monitor well shall be kept free of corrosion at all times. *[62-528.307(1)(f) and 62-528.307(2)(b), F.A.C.]*

3. Spillage onto the exploratory well or the monitor well pads during construction activities, and any waters spilled during mechanical integrity testing,

maintenance, testing, or repairs to the system shall be contained on the pads and discharged through an approved method of disposal. *[62-528.307(1)(f) and 62 528.307(2)(b), F.A.C.]*

4. After well construction activities are complete, the exploratory well pads are not, unless specific approval is obtained from the Department, to be used for storage of any material or equipment at any time. *[62 528.307(1)(f) and 62-528.307(2)(b), F.A.C.]*

5. Four surficial aquifer monitor wells, identified as Pad Monitor Wells (PMWs), shall be located near the corners of the pads to be constructed for the exploratory well and the monitor well, and shall be identified by number or pad location, i.e. NW, NE, SW, and SE. If located in a traffic area the well head(s) must be protected by traffic bearing enclosure(s) and cover(s). Each cover must lock and be specifically marked to identify the well and its purpose. The PMWs shall be sampled as follows:
   a. During the construction and associated testing phases, the PMWs shall be sampled weekly for chlorides (mg/L), specific conductance (μmhos/cm or μS/cm), field temperature, and water level relative to the North American Vertical Datum of 1988 (NAVD 88). Chlorides and specific conductance may be from field or lab samples.
   b. Initial PMW analyses shall be submitted prior to the onset of drilling activities.
   c. The PMWs shall also be sampled for total dissolved solids (mg/L, laboratory samples) during the first four weeks of PMW sampling and at all times when specifically requested by the Department.
   d. The results of the PMW analyses shall be submitted to the Department in the weekly progress report. The PMWs shall be retained in service throughout the construction phase of the project. Upon completion of construction, the permittee may submit a request to the Department for cessation of sampling followed by capping, or plugging and abandonment of these wells.

   [62-528.410(9)(b), F.A.C.]

IV. Quality Assurance/Quality Control

1. The permittee shall ensure that the construction of this exploratory well system shall be as described in the application and supporting documents. Any proposed modifications to the permit, construction procedures, testing procedures, completion procedures, or any additional work not described in the application or supporting documents shall be submitted in writing to the Aquifer Protection Program (APP) Tallahassee office for review and clearance prior to implementation. Changes of negligible impact to the environment and staff time will be reviewed by the program manager, cleared when appropriate and incorporated into this permit. Changes or modifications other than those described above will require submission of a completed application and appropriate processing fee as per Rule 62-4.050, F.A.C. *[62-4.050, F.A.C.]*

2. All water quality samples required by this permit shall be collected in accordance with the appropriate Department Standard Operation Procedures (SOP), pursuant to Chapter 62-160, F.A.C., Field Procedures. A certified laboratory shall conduct the analytical work, as provided by Chapter 62-160, F.A.C., Laboratory Certification. Department approved test methods shall be utilized, unless otherwise stated in this permit. All calibration procedures for field testing and laboratory equipment shall follow manufacturer's instrumentation manuals and satisfy the requirements of the Department SOPs. A listing of the SOPs pertaining to field and laboratory activities is available at the DEP website at: http://www.dep.state.fl.us/water/sas/sop/sops.htm *[62-4.246, 62-160, F.A.C.]*

3. All reports submitted to satisfy the requirements of this permit shall be signed by a person authorized under Rule 62-528.340(1), F.A.C., or a duly authorized representative of that person under Rule 62-528.340(2), F.A.C. All reports required by this permit which are submitted to the Department shall contain the following certification as required by Rule 62-528.340(4), F.A.C.:

   I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.
   [62-528.340(1), (2), and (4), F.A.C.]

4. Analyses shall be conducted on unfiltered samples, unless filtered samples have been approved by the Department as being more representative of groundwater conditions. *[62-520.310(5), F.A.C.]*

5. A professional engineer registered pursuant to Chapter 471, F.S., shall be retained throughout the construction period to be responsible for the construction operation and to certify the application, specifications, completion report, and other related documents. The Department shall be notified immediately of any change of engineer. *[62-528.440(5)(b), F.A.C.]*

6. Continuous on-site supervision by qualified personnel (engineer and/or geologist, as applicable) is required during all testing and geophysical logging operations. *[62-528.440(5)(b), F.A.C.]*

V. Reporting Requirements

1. The drilling and construction schedule, site layout of drilling pad, and pad monitor well locations shall be submitted to the Department during site

preparation but prior to drilling operation commencement for the exploratory well system. *[62-528.430(2)(a), F.A.C.]*

2. Weekly progress reports shall be submitted to the APP Tallahassee office and Southwest District offices throughout the construction period for each well. These reports, which may be submitted by electronic mail, shall be submitted within 48 hours of the end of the period of record and shall include at a minimum the following information:
   a. A cover letter summary of the daily engineer report, driller's log, and a projection for activities in the next reporting period.
   b. Daily engineer's reports and driller's/work logs with detailed descriptions of all drilling progress, cementing, testing, logging, and casing installation activities.
   c. Description of daily footage drilled by diameter of bit, size of hole opener, or reamer being used.
   d. Collection of drilling cuttings every 10 feet and at every formation change.
   e. Description of work during installation and cementing of casing, including amounts of casing and cement used. Details of cementing operations shall include the number of cementing stages, and the following information for each stage of cementing: the volume and type of cement pumped, the theoretical fill depth, and the actual tag depth. From both the physical tag and the geophysical logs, a percent fill shall be calculated. An explanation of any deviation between actual versus theoretical fill shall be provided.
   f. Details of the additions of salt or other materials to suppress well flow, including the date, depth, and amount of material used.
   g. Description of testing accomplished including (but not limited to) pumping and packer tests.
   h. Lithologic logs and core descriptions with cuttings description, formation and depth encountered.
   i. Geophysical logs, video logs, and deviation survey results.
   j. Water quality analyses, including but not limited to the weekly water quality analysis and water levels for the PMWs.
   k. Well development records.
   l. Description of any construction problems that developed during the reporting period and current status.
   m. Interpretations included with all test results and logs submitted.
   n. Documentation of disposal of drilling fluids, cuttings, formation water, or waste as per specific condition II.2.

   [62-528.410(9)(a) and 62-528.430(1), F.A.C.]

3. The final selection of specific potential injection and monitor intervals must be approved by the Department. In order to obtain an approval, the permittee shall submit a written request to the APP Tallahassee office. All casing seat requests for the exploratory well and the monitor well shall be accompanied by technical

justification. To the extent possible, each casing seat request should address the following items:

a. Lithologic and geophysical logs with interpretations, as the interpretations relate to the casing seat.
b. Water quality data (including but not necessarily limited to TDS concentrations).
c. Identification of confining units, including hydrogeologic data and interpretations.
d. Identification of monitor zones.
e. Casing depth evaluation (mechanically secure formation, potential for grout seal).
f. Lithologic drilling rate and weight on bit data, with interpretations (related to the casing seat).
g. Identification of the base of the USDW using water quality and geophysical log interpretations.
h. A certified (PE or PG) evaluation of all logging and test results submitted with test data.
i. Transmissivity or specific capacity of proposed monitor zone.
j. Packer test drawdown curves and interpretation.

[62-528.410(4)(c), 62-528.420(4)(c), F.A.C.]

4. The short-term injection test request shall contain the following justifications:
   a. Cement bond logs and interpretation.
   b. Final downhole television survey with interpretation.
   c. Demonstration of mechanical integrity, which shall include pressure testing results, and temperature logging results (if the injection test is to be after any of these mechanical integrity tests).
   d. Reasonable assurance that adequate confinement exists.
   e. Planned injection testing procedures.
   f. Proposed source water to be used. Wastewater may not be used for the test. An analysis of the proposed water source is required prior to Department approval, according to the table below:

Water Source	**Required Analyses**
Potable Water	No analysis needed.
Groundwater	Sample the water for: • total dissolved solids (mg/L) • chloride (mg/L) • specific conductance (temperature compensated, µmhos/cm or mS/cm) • total suspended solids (TSS) (mg/L) • nitrogen, ammonia, total as N (mg/L) • nitrogen, total Kjeldahl as N (TKN, mg/L) • nitrogen, nitrate, total as N (mg/L) • sodium (mg/L) • potassium (mg/L) • calcium (mg/L) • magnesium (mg/L) • total iron (mg/L) • bicarbonate (mg/L) • phosphorous, total as P (mg/L) • pH (standard units, s.u.) • sulfate, total as SO_4 (mg/L) • field temperature (°C) • gross alpha (picoCuries per liter [pCi/L]) • combined radium-226 and radium-228 (pCi/L)
Surface Water	As above for groundwater, with the additional constituents: • total coliform (CFU/100ML) • fecal coliform (cfu/100mL) • *Escherichia coli* (cfu/100mL) • Enterococci (cfu/100mL) • turbidity (Nephelometric Turbidity Unit [NTU])

[62-528.405(3)(b), F.A.C.]

5. Upon completion of analysis of cores and sample cuttings recovered during the construction of wells covered by this permit (when no longer needed by the well owner), the permittee shall contact the Geological Sample Acquisition & Management Section of the Florida Geological Survey (FGS) to arrange for the transfer of the cores and cuttings. *[62-528.450(5), F.A.C.]*

6. All cores and cuttings for FGS shall be shipped to the Florida Geological Survey, Geological Sample Acquisition & Management Section, 3915 Commonwealth Boulevard, Tallahassee, Florida 32399. All cores and samples shall clearly identify the site name, well name/number, depths of samples/cores, and the

latitude/longitude location of the well(s) using the form in this permit. *[62-528.450(5), F.A.C.]*

7. A final report of the construction and testing of the exploratory well and the monitor well shall be submitted no later than 120 days after the completion of well construction and testing, pursuant to Rule 62-528.430(1)(e), F.A.C. In addition, a copy of the cover letter for the report shall be sent to the U. S. Environmental Protection Agency, Region 4, UIC program, 61 Forsyth St. SW, Atlanta, Georgia 30303-8909, or R4gwuic@EPA.gov. This report shall include as a minimum, definitions of the potential injection interval, all relevant confining units, all monitor zones, and the depth of the base of the USDW, including all relevant data and interpretations. *[62-528.605(2), F.A.C.]*

VI. Abnormal Events

1. In the event the permittee is temporarily unable to comply with any of the conditions of a permit due to breakdown of equipment, power outages or destruction by hazard of fire, wind, or by other cause, the permittee of the facility shall notify the Southwest District. *[62-528.415(4)(a), F.A.C.]*

2. Notification shall be made in person, by telephone, or by electronic mail (e-mail) within 24 hours of breakdown or malfunction to the Southwest District Office. *[62-528.307(1)(x), F.A.C.]*

3. A written report of any noncompliance referenced in Specific Condition Number VI.1. above shall be submitted to the Southwest District Office and the APP Tallahassee office within five days after its occurrence. The report shall describe the nature and cause of the breakdown or malfunction, the steps being taken or planned to be taken to correct the problem and prevent its reoccurrence, emergency procedures in use pending correction of the problem, and the time when the facility will again be operating in accordance with permit conditions. *[62-528.415(4)(b), F.A.C.]*

4. **Reporting Requirements**

   The permittee shall report to the Department's Southwest District Office any noncompliance which may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances. The written submission shall contain: A description of the noncompliance and its cause; the period of noncompliance including exact dates and time, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.

a. The following shall be included as information which must be reported within 24 hours under this condition:
   1) Any unanticipated bypass which causes any reclaimed water or effluent to exceed any permit limitation or results in an unpermitted discharge,
   2) Any upset which causes any reclaimed water or the effluent to exceed any limitation in the permit,
   3) Violation of a maximum daily discharge limitation for any of the pollutants specifically listed in the permit for such notice, and
   4) Any unauthorized discharge to surface or groundwaters.
b. Oral reports as required by this subsection shall be provided as follows:
   1) For unauthorized releases or spills of treated or untreated wastewater reported pursuant to subparagraph (a)4. that are in excess of 1,000 gallons per incident, or where information indicates that public health or the environment will be endangered, oral reports shall be provided to the **State Watch Office Toll Free Number** 800-320-0519, as soon as practical, but no later than 24 hours from the time the permittee becomes aware of the discharge. The permittee, to the extent known, shall provide the following information to the State Watch Office:
      a) Name, address, and telephone number of person reporting;
      b) Name, address, and telephone number of permittee or responsible person for the discharge;
      c) Date and time of the discharge and status of discharge (ongoing or ceased);
      d) Characteristics of the wastewater spilled or released (untreated or treated, industrial or domestic wastewater);
      e) Estimated amount of the discharge;
      f) Location or address of the discharge;
      g) Source and cause of the discharge;
      h) Whether the discharge was contained on-site, and cleanup actions taken to date;
      i) Description of area affected by the discharge, including name of water body affected, if any; and
      j) Other persons or agencies contacted
   2) Oral reports, not otherwise required to be provided pursuant to subparagraph b.1 above, shall be provided to the Department's Southwest District office within 24 hours from the time the permittee becomes aware of the circumstances.
c. If the oral report has been received within 24 hours, the noncompliance has been corrected, and the noncompliance did not endanger health or the

environment, the Department's Southwest District office shall waive the written report.

[403.077(2)(d), F.S., 62-528.307(1)(e) and 62-528.307(1)(x), F.A.C.]

5. **Pollution Notification**
   a. In accordance with subsection 403.077, F.S., in the event of a reportable pollution release, an owner or operator of the installation at which the reportable pollution release occurs must provide to the department information reported to the State Watch Office within the Division of Emergency Management pursuant to any department rule, permit, order, or variance, within 24 hours after the owner's or operator's discovery of such reportable pollution release. The Department's Pollution Notice website is at https://FloridaDEP.gov/pollutionnotice.
   b. If multiple parties are subject to the notification requirements based on a single reportable pollution release, a single notification made by one party in accordance with this section constitutes compliance on behalf of all parties subject to the requirement. However, if the notification is not made in accordance with this section, the department may pursue enforcement against all parties subject to the requirement.
   c. If, after providing notice pursuant to paragraph (a), the owner or operator of the installation determines that a reportable pollution release did not occur or that an amendment to the notice is warranted, the owner or operator may submit a letter to the department documenting such determination.
   d. If, after providing notice pursuant to paragraph (a), the installation owner or operator discovers that a reportable pollution release has migrated outside the property boundaries of the installation, the owner or operator must provide an additional notice to the department that the release has migrated outside the property boundaries within 24 hours after its discovery of the migration outside of the property boundaries.

[403.077(2)(d), F.S., 62-528.307(1)(e) and 62-528.307(1)(x), F.A.C.]

General Conditions

1. The terms, conditions, requirements, limitations and restrictions set forth in this permit are "permit conditions" and are binding and enforceable pursuant to section 403.141, F.S. *[62-528.307(1)(a)]*

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action. *[62-528.307(1)(b), F.A.C.]*

3. As provided in subsection 403.087(7), F.S., the issuance of this permit does not convey any vested rights or exclusive privileges. Neither does it authorize any injury to public or private property or any invasion of personal rights, nor infringement of federal, state, or local laws or regulations. This permit is not a waiver of or approval of any other Department permit that may be required for other aspects of the total project which are not addressed in this permit. *[62-528.307(1)(c), F.A.C.]*
4. This permit conveys no title to land, water, does not constitute State recognition or acknowledgment of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the State. Only the Trustees of the Internal Improvement Trust Fund may express State opinion as to title. *[62-528.307(1)(d), F.A.C.]*
5. This permit does not relieve the permittee from liability for harm to human health or welfare, animal, or plant life, or property caused by the construction or operation of this permitted source, or from penalties there from; nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department. *[62-528.307(1)(e), F.A.C.]*
6. The permittee shall properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed and used by the permittee to achieve compliance with the conditions of this permit or are required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules. *[62-528.307(1)(f), F.A.C.]*
7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law and at reasonable times, access to the premises where the permitted activity is located or conducted to:
   a. Have access to and copy any records that must be kept under conditions of this permit;
   b. Inspect the facility, equipment, practices, or operations regulated or required under this permit; and
   c. Sample or monitor any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules.
   d. Reasonable time will depend on the nature of the concern being investigated.

   [62-528.307(1)(g), F.A.C.]

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately provide the Department with the following information:
   a. A description of and cause of noncompliance; and
   b. The period of noncompliance, including dates and times; or, if not corrected the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent the recurrence of the noncompliance. The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or for revocation of this permit.

   [62-528.307(1)(h), F.A.C.]
9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source which are submitted to the Department may be used by the Department as evidence in any enforcement case involving the permitted source arising under the Florida Statutes or Department rules, except where such use is proscribed by sections 403.111 and 403.73, F.S. Such evidence shall only be used to the extent it is consistent with the Florida Rules of Civil Procedure and appropriate evidentiary rules. *[62-528.307(1)(i), F.A.C.]*
10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance; provided, however, the permittee does not waive any other rights granted by Florida Statutes or Department rules. *[62-528.307(1)(j), F.A.C.]*
11. This permit is transferable only upon Department approval in accordance with rules 62-4.120 and 62-528.350, F.A.C. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department. *[62-528.307(1)(k), F.A.C.]*
12. This permit or a copy thereof shall be kept at the work site of the permitted activity. *[62-528.307(1)(l), F.A.C.]*
13. The permittee shall comply with the following:
    a. Upon request, the permittee shall furnish all records and plans required under Department rules. During enforcement actions, the retention period for all records shall be extended automatically unless the Department determines that the records are no longer required.
    b. The permittee shall hold at the facility or other location designated by this permit records of all monitoring information (including calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation) required by the permit, copies of all reports required by this permit, and records of all data used to complete the application for this permit. These materials shall be retained at least three

years from the date of the sample, measurement, report, or application unless otherwise specified by Department rule.

c. Records of monitoring information shall include:
   1) the date, exact place, and time of sampling or measurements;
   2) the person responsible for performing the sampling or measurements;
   3) the dates analyses were performed;
   4) the person responsible for performing the analyses;
   5) the analytical techniques or methods used;
   6) the results of such analyses.

d. The permittee shall furnish to the Department, within the time requested in writing, any information which the Department requests to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit.

e. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be corrected promptly.

[62-528.307(1)(m), F.A.C.]

14. All applications, reports, or information required by the Department shall be certified as being true, accurate, and complete. *[62-528.307(1)(n), F.A.C.]*

15. Reports of compliance or noncompliance with, or any progress reports on, requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each scheduled date. *[62-528.307(1)(o), F.A.C.]*

16. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. *[62-528.307(1)(p), F.A.C.]*

17. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit. *[62-528.307(1)(q), F.A.C.]*

18. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this permit. *[62-528.307(1)(r), F.A.C.]*

19. This permit may be modified, revoked and reissued, or terminated for cause, as provided in 40 C.F.R. sections 144.39(a), 144.40(a), and 144.41 (1998). The filing of a request by the permittee for a permit modification, revocation or reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition. *[62-528.307(1)(s), F.A.C.]*

20. The permittee shall retain all records of all monitoring information concerning the nature and composition of injected fluid until five years after completion of any plugging and abandonment procedures specified under rule 62-528.435, F.A.C. The permittee shall deliver the records to the Department office that issued the permit at the conclusion of the retention period unless the permittee elects to continue retention of the records. *[62-528.307(1)(t), F.A.C.]*

21. All reports and other submittals required to comply with this permit shall be signed by a person authorized under rules 62-528.340(1) or (2), F.A.C. All reports shall contain the certification required in rule 62-528.340(4), F.A.C. *[62-528.307(1)(u), F.A.C.]*

22. The permittee shall notify the Department as soon as possible of any planned physical alterations or additions to the permitted facility. In addition, prior approval is required for activities described in rule 62-528.410(1)(h). *[62-528.307(1)(v), F.A.C.]*

23. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or injection activity which may result in noncompliance with permit requirements. *[62-528.307(1)(w), F.A.C.]*

24. The permittee shall report any noncompliance which may endanger health or the environment including:
    a. Any monitoring or other information which indicates that any contaminant may cause an endangerment to an underground source of drinking water; or
    b. Any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between underground sources of drinking water.

    Any information shall be provided orally within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.
    [62-528.307(1)(x), F.A.C.]

Issued this (Day) day of (Month) 2024

State of Florida
Department of Environmental Protection

____

Richard Lobinske, Ph.D.
Environmental Administrator
Underground Injection Control
Aquifer Protection Program
Division of Water Resource Management

Fact Sheet

Mosaic Fertilizer, LLC
Plant City Concentrate
Class V, Group 9
Permit Number: 0441607-001-UC/1EX
WACS ID: 108119
November 22, 2024

Construction permit for the Mosaic Plant City Concentrate Class V, Group 9, exploratory injection well IW-1 and associated monitor well DZMW-1.

1. General Information

A. Statutory Basis for Requiring/Issuing Permit

The Department of Environmental Protection (Department or DEP) has permitting jurisdiction under Chapter 403, Florida Statutes (F.S.), and the rules adopted thereunder. The project is not exempt from permitting procedures. The Department has determined that an Underground Injection Control permit is required for the project.

B. Name and Address of Applicant

Scott Wuitschick
Geotechnical Director
Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Florida 33547
Scott.Wuitschick@MosaicCo.com

Facility Location

Mosaic Plant City Concentrate Facility
10609 Paul S Buchman Hwy
Plant City, Florida 33565
Hillsborough County

C. Description of Applicant's Operation

To construct one non-hazardous Class V, Group 9, exploratory well (IW-1) at the Mosaic Fertilizer, LLC, Plant City Concentrate Facility. No injection is authorized by this permit with the exception of a short-term injection test to test the suitability of the proposed injection zone.

The permittee will later apply for well reclassification as a non-hazardous Class I injection well for the disposal of non-hazardous phosphogypsum stack system (gyp-stack) industrial wastewater stored in the Mosaic Plant City Concentrate Facility, the phreatic water collected by the gyp-stack underdrain system, and recovery well water from the Mosaic Plant City Concentrate Facility. Injectate will be limited to wastewater generated and treated at the Mosaic Plant City facility and regulated under its National Pollutant Discharge Elimination System Permit (FL0000078).

The primary proposed location for IW-1 is latitude 28° 08' 51.25" N and longitude 82° 08' 19.08" W and the secondary location is latitude 28° 09' 44.87" N and longitude 82° 08' 29.90" W.

IW-1 is proposed to be constructed with a 20-inch diameter casing set to 3,610 feet below land surface (bls), an 11.75-inch diameter tubing set to 3,610 feet bls with a cemented annulus, and total depth of 8,000 feet bls.

D. Permitting History of this Facility

1. This is the first injection well permit application associated with this facility.

E. Documents Used in Permitting Process

1. Black & Veatch "Mosaic Plant City Facility Exploratory Well IW-1 Florida Department of Environmental Protection Class V, Group 9, Exploratory Injection Well Construction Permit Application dated October 17, 2023.
2. DEP First Request for Additional Information dated January 16, 2024 – RAI request 1
3. Black & Veatch "Mosaic Plant City First Request for Additional Information (RAI) dated February 15, 2024 – RAI response
4. Black & Veatch Application Addendum dated May 29, 2024.
5. Black & Veatch Revised Application Addendum figure received July 2, 2024.

2. Reasons Permit was Issued, Derivation of Decision

A. Area of Review (Rule 62-528.440(6), Florida Administrative Code (F.A.C.))

According to the construction permit application, an area of review (AOR) radius of 1 mile was established based on a projected horizontal extent of influence from the facility. The area of review was completed for both the primary and secondary proposed locations. Based on the completion of an AOR study the applicant did not identify any wells within the AOR that were not properly constructed or abandoned and none of the wells identified in the AOR extend to the depth of the proposed confining or injection zones.

The AOR radius calculation using an estimated 4.0 mgd volume over a 10 year period resulted in a radius of 0.75 miles. The result was rounded up to 1 mile. The estimate is considered to be conservative because the AOR represents a radius 1 mile from the Mosaic property boundary which is a greater distance than if it were from either the primary or secondary proposed well locations located within the Mosaic property boundary.

The primary proposed injection well location is at latitude 28° 08' 51.25" N and longitude 82° 08' 19.08" W and the secondary proposed injection well location is at latitude 28° 09' 43.02" N and longitude 82° 08' 29.90" W.

See Documents Used in the Permitting Process (Document) number 1, above.

B. Mechanical Integrity Demonstration (Rule 62-528.300(6), F.A.C.)

Mechanical integrity of injection well IW-1 will be demonstrated during construction by the following methods:

1. A cement-top temperature log will be performed in each casing string after each cementing stage that does not result in cement returns at surface.
2. A cement bond log (CBL) will be run in the 20-inch final casing of IW-1 after cementing.
3. A pressure tests will be performed in the 20-inch diameter casing at 150 pounds per square inch (psi) for 1 hour.

4. A video survey of the completed injection well will be conducted.
5. A CBL will be run in the nominal 11.75-inch injection tubing before and after cementing.
6. A pressure test will be performed in the 11.75-inch injection tubing after it is cemented, at a minimum of 50 psi for 1 hour. Pressure changes will be considered acceptable if they are within the 5% limit allowed by the Department.
7. Temperature and radioactive tracer surveys will be performed in IW-1 to demonstrate external mechanical integrity after construction is completed.

Mechanical integrity of monitor well DZMW-1 will be demonstrated during construction by the following methods:

1. A cement-top temperature log will be performed in each casing string after each cementing stage that does not result in cement returns at surface.
2. A CBL will be run on the 16-inch casing prior to cementing the a final CBL will be run once cement is approximately 300 feet from the surface.
3. A pressure test will be performed in the 16-inch casing of DZMW-1 after it is cemented, at a minimum of 150 psi for 1 hour.
4. A CBL will be run in the 7-inch casing of DZMW-1 before and after it is cemented.
5. A pressure test will be performed in the 7-inch casing of DZMW-1 after it is cemented, at a minimum of 50 psi for 1 hour. Pressure changes will be considered acceptable if they are within the 5% limit allowed by the Department.
6. Video and temperature surveys of the 7-inch casing of DZMW-1 will be conducted after construction of the well is completed.

See Document number 1, above.

C. Confinement (Rule 62-528.405(2), F.A.C.)

According to the construction application, the proposed injection well IW-1 will be reclassified from Class V to Class I after construction. It is anticipated that there is sufficient confinement below the base of the Underground Source of Drinking Water (USDW). Based on the information presented in the application, the Sub-Floridan Confining Unit is expected to occur between approximately 2,720 feet bls and the top of the proposed injection zone at 3,610 feet bls.

Rock cores will be collected at select depths between the base of the USDW and the top of the injection zones. Representative sections of each acceptable core are to be analyzed for vertical and horizontal hydraulic conductivity, porosity, and specific gravity. A minimum of four packer tests will be performed to characterize the Cretaceous strata. The presence and degree of confinement above the injection zone will be evaluated based on the core analyses, packer-pump testing, and wireline geophysical logging results.

See Document numbers 1-5, above.

D. Underground Source of Drinking Water (Rule 62-528.405(1)(a), F.A.C.)

The USDW is an aquifer or its portion that supplies drinking water for human consumption, is classified by subsection 62-520.410(1), F.A.C., as Class F-I, G-I or G-II ground water, or contains total dissolved solids (TDS) of less than 10,000 milligrams per liter (mg/L) and is not an exempted aquifer. The interface where the concentration of TDS in groundwater exceeds 10,000 mg/L is defined by rule as the base of a USDW.

The anticipated base of the USDW at the proposed injection site is in Oldsmar Formation of the Lower Floridan aquifer at approximately 2,600 feet bls. The actual depth of the base of the USDW will be determined during IW-1 and DZMW-1 construction and testing. Data collection will include analyses of reverse-air discharge fluids during drilling, analyses of packer-pumping test water samples, and wireline geophysical logging.

See Document number 1, above.

E. Injection Zone Testing (Rule 62-528.405(2)&(3), F.A.C.)

Injection zone testing will be performed through water quality testing, core analyses, wireline geophysical logs, and short-term injection testing in IW-1. The proposed injection zone is from a depth of approximately 3,610 to 8,000 feet bls in the Upper Cretaceous Permeable Zone.

Except for a short-term injection test, injection is prohibited until the permittee is issued a Class I injection well permit. The proposed short-term injection test will be conducted at 2,775 gpm for 12 hours.

See Document numbers 1-5, above.

F. Well Construction

The conventional mud-rotary drilling method will be employed for all drilling above the base of the surface casings set near the top of the Floridan Aquifer System. Drilling below that point will be done by the reverse-air, closed-circulation method. A drilling pad shall be provided to collect spillage of contaminants and to support the heaviest load that will be encountered during drilling. All casings shall be new and unused, designed for the life expectancy of the well, and cemented to land surface in accordance with Rule 62-528.410(4)(a).

The proposed, cemented annulus between the 20-inch OD injection casing and the nominal 11.75-inch injection tubing is an alternate design to that specified in Rule 62-528.415(1)(e), F.A.C. This alternate design has been demonstrated to reliably provide a comparable level of protection to the USDW at other facilities and is approved in accordance with 62-528.410(1)(e)1., F.A.C.

According to the applicant, the proposed casings will serve to isolate individual production zones within the USDW. The 60-inch diameter steel pit casing depth will be decided by the onsite geologist. Once the pit casing is installed, a pilot hole will be drilled to allow testing to determine the base of the surficial aquifer. The 50-inch diameter steel surface casing will be installed to approximately 330 feet bls and terminate in the closest confining unit (Hawthorn Group). The purpose of the surface casing is to isolate the surficial aquifer. The 40-inch diameter steel intermediate casing will be installed to an estimated 1,100 feet bls and isolate the Upper Floridan aquifer and extend into the Middle Confining Unit II of the Avon Park Formation. The 30-inch diameter steel intermediate casing will be installed to an estimated

3,000 feet bls to isolate the Lower Floridan aquifer and will extend into the Sub-Floridan Confinement (Cedar Keys Formation). The final 20-inch diameter steel casing will be installed to an estimated depth of 3,610 feet bls in the Upper Cretaceous Permeable Zone (Cedar Keys Formation). The 11.75-inch Red Box 1250 FRP injection tubing will be installed at an estimated depth of 3,600 feet bls. A cementing packer assembly will be installed between the final casing and injection tubing from approximately 3,600 feet bls to approximately 3,610 feet bls.

Table 1
Exploratory Well

Well Name	WACS Testsite ID	Well Depth (Feet bls)	Casing Size (Inches)[a]	Casing Thickness (Inches)	Casing or Tubing Type	Casing Depth or Interval (Feet bls)
IW-1	14247	8,000	60	0.5	Steel	TBD[c]
			50	0.5	Steel	330
			40	0.5	Steel	1,100
			30	0.5	Steel	3,000
			20	0.5	Steel	3,610
			11.75	0.49	FRP[b]	3,600
					Open Hole	3,610 – 8,000

Exploratory Well Notes: IW-1 will be constructed with new, unused well materials and fully cemented to land surface. [a]All sizes are outside diameter or nominal size. [b]Fiberglass-reinforced plastic (FRP) Red Box® series 1250 tubing with 10.72-inch inside diameter. [c]To be determined (TBD) by onsite geologist during well construction.

See Document numbers 1-5, above.

G. Monitor Plan (Rule 62-528.425(1), F.A.C.)

No injection is allowed into IW-1 with the exception of a short-term injection test using potable water discussed in the Injection Zone Testing section.

If IW-1 is converted from a Class V exporatory well to a Class I injection well, the dual-zone monitor well DZMW-1 will be constructed within 150 feet of IW-1 for monitoring groundwater quality in the aquifer above the injection zone to detect upward migration of injected fluids out of the injection zone that might occur. The upper zone will monitor groundwater quality within the USDW, and the lower monitor zone will serve as early warning detection.

An injection zone background water quality sample will be collected during exploratory well development.

See Document number 1 above.

H. Financial Responsibility (Rule 62-528.435(9) and 62-528.455(3)(b)8 and (3)(c)3, F.A.C.)

Not required by Chapter 62-528, F.A.C. for this exploratory Class V, Group 9 well. However, financial responsibility will be required, if the well is later converted to a Class Injection well.

I. Emergency Discharge (Rule 62 528.450(2)(k), F.A.C.)

Not required by Chapter 62-528, F.A.C. for this exploratory Class V, Group 9, well to cope with shut-ins or well failures because no injection is allowed with the exception of a short-term injection test. However, emergency discharge will be required, if the well is later converted to a Class I injection well.

Drilling/Construction:

1. A drilling pad shall be provided to collect spillage of contaminants (62-528.410(9)(b), F.A.C.).
2. Flow control shall be used when drilling into formations in which pressure heads exceed land surface, to prevent the uncontrolled release of formation or drilling fluids at land surface (62-528.410(9)(c), F.A.C.).
3. At a minimum, all salt and on-site, stockpiled additive materials shall be secured to prevent surface and/or groundwater contamination, and all drilling equipment shall be properly secured to prevent damage to well(s) and on-site treatment processes upon the issuance of a “Hurricane Watch” by the National Weather Service (62-528.307(1)(f), F.A.C.).

3. Agency Action

A draft permit will be issued as per Rule 62-528.310, F.A.C.

4. Public Rights

Public notice of this draft permit will include the details of a public meeting, or will state that any interested person may request a public meeting within 30 days of the public notice. A request for a public meeting shall be in writing and shall state the nature of the issues proposed to be raised at the meeting. If a public meeting is later scheduled, there will be another 30-day notice period for that meeting. Any interested person may submit written comments on the draft permit within 30 days of the public notice or through the public meeting date, as appropriate. Written comments or a public meeting request may be submitted to the Department of Environmental Protection, Aquifer Protection Program, 2600 Blair Stone Road, MS 3530, Tallahassee, Florida 32399-2400. All comments received within the 30-day period and through the public meeting date will be considered in formulation of the Department’s final decision regarding permit issuance.

After the conclusion of the public comment period and public meeting described above the Department may revise the conditions of the permit based on such public comment. Then the applicant will publish Notice of the Proposed Agency Action. A person whose substantial interests are affected by the Department's proposed permitting decision may petition for an administrative proceeding (hearing). Accordingly, the Department's final action may be different from the position taken by it in the Notice of the Proposed Agency Action. The petition must conform to the requirements specified in the Notice and be filed (received) within 14 days of publication of the Notice in the Office of General Counsel, M.S. 35, 3900 Commonwealth Boulevard, Tallahassee, Florida 32399-3000. The failure of any person to file a Petition within the appropriate time period shall constitute a waiver of that person’s right to request an administrative (hearing) under Section 120.569 and Section 120.57 of the Florida Statutes, or to intervene in this proceeding and participate as a party to it. Any subsequent intervention (in a proceeding initiated by another party) will only be at the discretion of the presiding officer upon filing of a motion in compliance with Rule 28-106.205 of the Florida Administrative Code.

The application, draft permit, and fact sheet are available for public inspection during normal business hours, 8 a.m. to 5 p.m., Monday through Friday, except legal holidays, at the Department of Environmental Protection, Southwest District Office, 13051 N. Telecom Parkway, Temple Terrace, Florida 33637-0926, and at the Department of Environmental Protection, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400. Additional information related to this project may be requested from the Agency Contact below.

5. Agency Contact

Walsta Jean-Baptiste, P.G.
Aquifer Protection Program
Florida Department of Environmental Protection
2600 Blair Stone Road, MS 3530
Tallahassee, Florida 32399-2400
Phone: 850-245-8386
Walsta.JeanBaptiste@FloridaDEP.gov

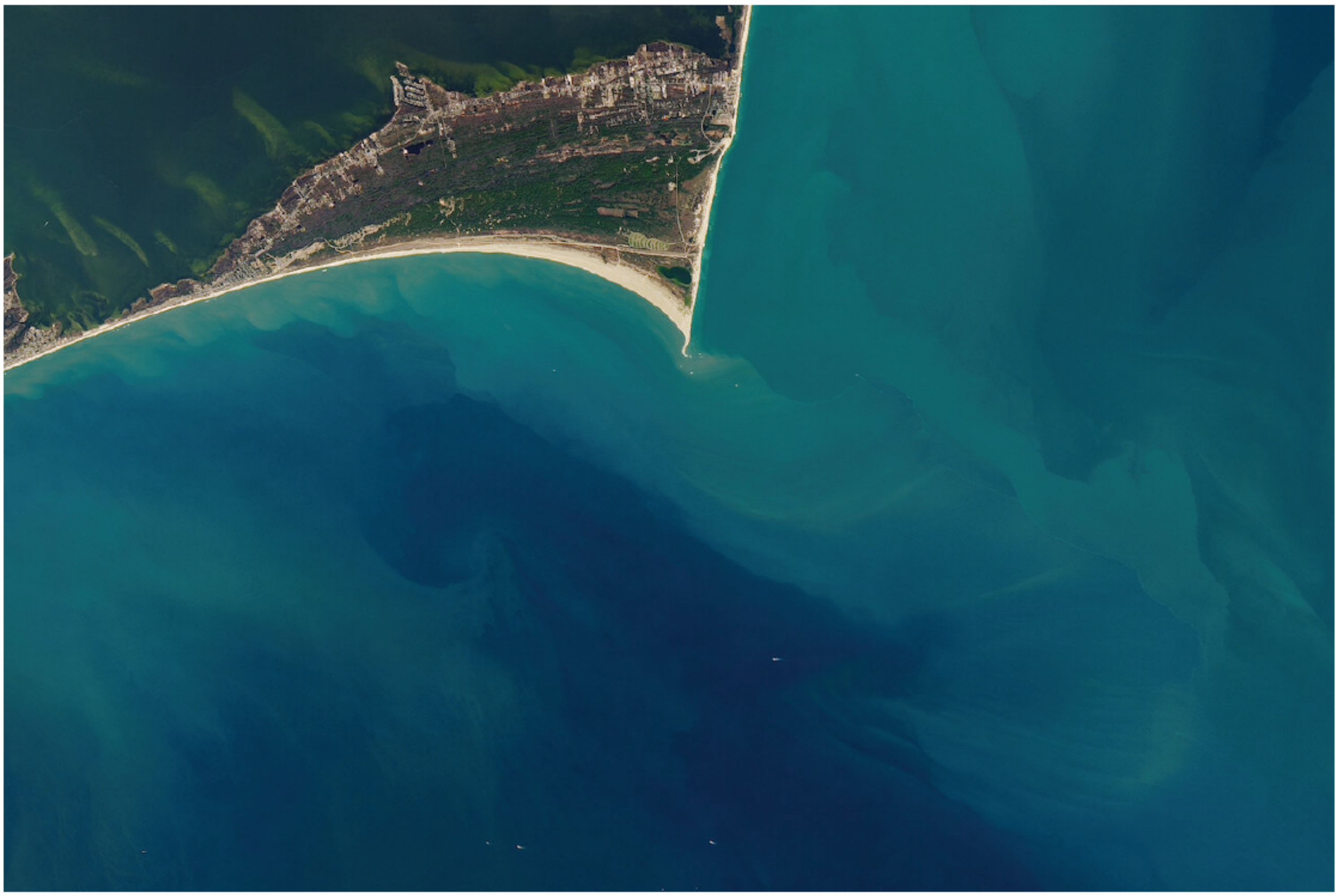
DATA

SEA LEVEL CHANGE
Observations from Space

NEWS | June 6, 2023

Why Seas are Rising Faster on the Southeast Coast

By Ethan Huang, NASA's Sea Level Change Team



Cape Hatteras. Image credit: Jesse Allen and Joshua Stevenson for NASA Earth Observatory

The question: What is the source of accelerated sea level rise in the United States' Southeast and Gulf coasts?

The answer: Sea level rise is not the same everywhere. In a recent study, researchers discovered that sea level in the Gulf Coast region is accelerating faster than in the past.

Newsletter

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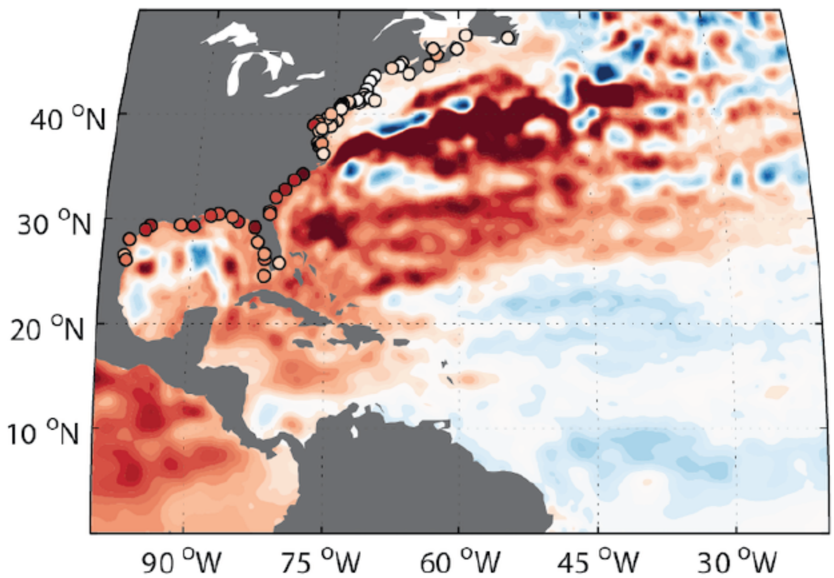
"We found that the area from Cape Hatteras at the Outer Banks into the Gulf of Mexico had a very high acceleration in the rates of sea level rise, with rates that were in excess of 10 millimeters per year," said lead author Sönke Dangendorf, the David and Jane Flowerree Assistant Professor at Tulane University and member of the NASA Sea Level Change Team. "That's approximately five times the amount that we have observed on average over the entire 20th century at these locations."



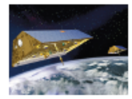
A map of the Gulf Coast region. Darker red regions represent a faster acceleration in the rate of sea level rise while lighter blue regions represent sea level deceleration. Image courtesy of Sönke Dangendorf

Although the average acceleration of global sea level rise has also increased over the decades, it was mainly due to melting ice in regions like Greenland. For the Gulf Coast, the team used tide-gauge readings and satellite data from NASA missions like GRACE to rule out a few potential causes.

"We checked vertical land motion, for instance, and could relatively quickly say no," he said. "We looked into the ice-melt component but it couldn't explain the magnitude of the change that we have seen in that particular area."

This left them with one other possibility: sterodynamic sea level, or the combination of ocean-water expansion in response to warming, saltiness, and ocean circulation. The team found that beyond Cape Hatteras, this acceleration extended into the North Atlantic and the Caribbean Sea.

Related Missions



GRACE
The twin GRACE satellites mapped Earth's gravitational field to improve investigation of water re...

But what is the source of this shifting circulation? According to Dangendorf, climate models reveal two factors at play.

“Approximately 40% of the acceleration that we have seen since 2010 can be attributed to man-made climate change, but there’s a residual 60% that we couldn’t explain with climate models,” said Dangendorf.

The remaining percentage was caused by natural wind-driven ocean circulation unique to the Southeast and Gulf Coast, the researchers found.

“It’s a region bounded by the western boundary current, or the Gulf Stream, so that makes it very prone to fluctuations and therefore we can see these massive changes on decadal time-scales,” said Dangendorf.

Why it’s important: Accelerated sea level rise and continued global warming will affect local communities, Dangendorf said

“One thing that is particularly visible over this period of acceleration is that the high-tide flooding has on average doubled in the Gulf of Mexico,” he said. “We are very close to threshold that any further increase in the rate of sea level rise will lead to substantially larger, exponential changes in high-tide flooding, bringing a big burden for many of the communities in the area that haven’t dealt with that much before.”

This is on top of the damages caused by seasonal hurricanes like Katrina or Sandy that are expected to become more frequent due to climate change. The community may need to prepare for these risks.

Dangendorf says that the next step is to expand their researc along the entire coast.

“We want to understand how these acceleration hotspots shif along the coastline, and the role of ocean dynamics,” he said. “We want to investigate how we can understand these natura fluctuations, and better predict them into the near future.”

Site Manager: Carmen Blackwood
NASA Responsible Official: Stephen Berrick

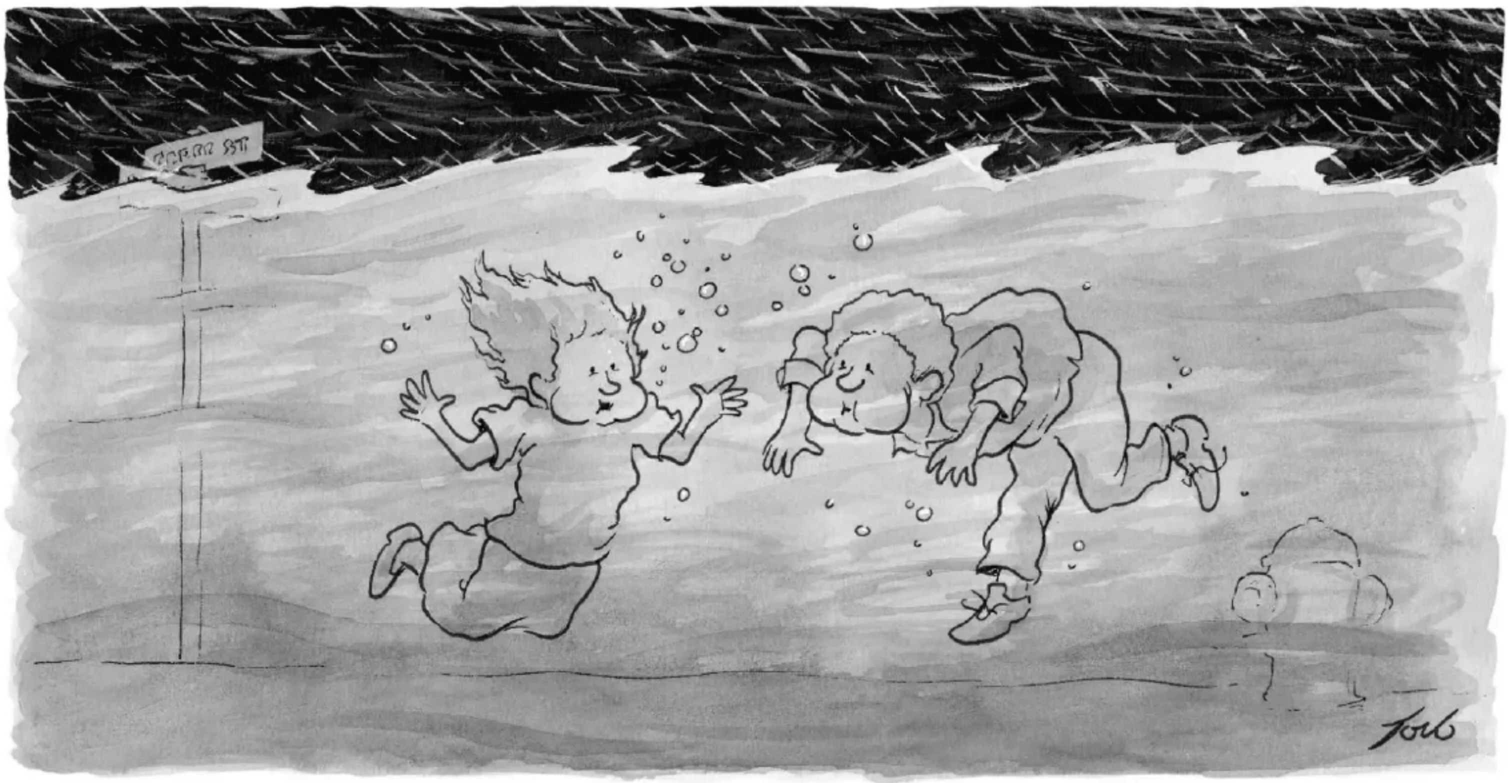
YALE Climate Connections

CLIMATE EXPLAINED

How climate change is making hurricanes more dangerous

Stronger wind speeds, more rain, and worsened storm surge add up to more potential destruction.

by **JEFF BERARDELLI**
JULY 8, 2019



"At least the torrential rain protects us from the gale-force winds!"

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Major hurricanes are by far the world's **costliest** natural weather disasters, in some cases causing **over** $100 billion in damage. There's now evidence that the unnatural effects of human-caused

global warming are already making hurricanes stronger and more destructive. The latest research shows the trend is likely to continue as long as the climate continues to warm.

How does a hurricane form?

Whether called hurricanes in the Atlantic Ocean, typhoons in the western Pacific Ocean, or cyclones in the Indian Ocean, strong tropical cyclones are an example of nature's fiercest fury.

The criteria that conspire to form tropical cyclones are rather simple. It all starts with a small atmospheric disturbance located in or near a tropical ocean. If water temperatures are warm enough, generally more than 80 degrees Fahrenheit, and atmospheric conditions are supportive with moisture and uniform winds, a tropical system can evolve. In the Atlantic the system first becomes a tropical depression. As it gets stronger the system graduates to a tropical storm and then finally, when winds rise over 74 mph, it is termed a hurricane.

Are hurricanes becoming more frequent?

Generally speaking, the warmer the water temperatures, the more heat energy is available and the higher the potential for tropical cyclones to develop. So it's reasonable to assume that as humans continue to release planet-warming greenhouse gases, the likelihood of tropical cyclone activity increases.

By and large, that is true, but in the real world it's a little more complicated than that. The conventional wisdom is that storm intensity will increase but storm frequency will either decrease or remain unchanged.

Finding trends in either the number or intensity of tropical cyclones is complicated because reliable records date back only as far as consistent and complete global satellite observations. Since 1985, a remarkably consistent average of approximately **80 tropical cyclones** has formed each year, **ranging** from a low of 65 to a maximum of 90.

In terms of frequency, studies have consistently **shown** "no discernible trend in the global number of tropical cyclones." In addition, authors of a 2013 **study** found no human-caused signal in annual global tropical cyclone or hurricane frequencies.

Are hurricanes getting stronger?

The authors of that same 2013 **study** found a substantial regional and global increase in the proportion of the strongest hurricanes category 4 and 5 storms. The authors attribute that increase to global heating of the climate: "We conclude that since 1975 there has been a substantial and observable regional and global increase in the proportion of Cat 4-5 hurricanes of 25-30 percent per °C of anthropogenic (human-caused) global warming."

Interestingly, the increase in those most powerful of storms is balanced by a similar decrease in category 1 and category 2 hurricanes. The authors put forth this intriguing theory: "We suggest that this [balance] arises from the capped nature of tropical cyclones to a maximum value defined by the potential intensity, which increases only slightly with global warming."

Are hurricanes intensifying more rapidly?

Rapid intensification, defined as an increase of wind speed of at least 35 mph in 24 hours, has recently garnered a lot of attention as a result of hurricanes like Harvey, Irma, Maria and Michael in 2017 and 2018. Examining the hurricane record in the Atlantic basin from 1986 to 2015, a recent **study** found rapid intensification increased 4.4 mph per decade. The study's authors attribute most of the gains to a shift into the warmer phase of the Atlantic Multidecadal Oscillation, a natural cycle.

But the authors of a 2019 **paper** led by scientists at NOAA's Geophysical Fluid Dynamics Laboratory suggest that global warming also plays a role. Using simulations from one of the most advanced climate models available, called HiFLOR, the team of researchers concludes that recent increases in rapid intensification "is outside HiFLOR's estimate of expected internal climate variability which suggests the model's depiction of climate oscillations like the AMO cannot explain the observed trend."

So while the team cannot attribute the rapid intensification gains to human-caused warming, they do say human-caused warming significantly increases extreme tropical cyclone intensification rates in the HiFLOR model.

Are hurricanes producing more rain?

When it comes to the link between a warming world and weather, one of the most well-understood and **robust connections** is increased rainfall. Simply put, the warmer the air is, the more moisture it can hold and the more rain it produces. Generally, the increase in rainfall follows the Clausius-Clapeyron equation, which dictates that for every one degree Celsius (1.8 degrees Fahrenheit) increase, the atmosphere can hold 7% more moisture.

This increase in moisture and rainfall does not fall uniformly; in tropical cyclones this effect is boosted. In a 2018 **paper** about the link between increasing ocean heat content and hurricanes, lead author Kevin Trenberth of the National Center for Atmospheric Research explains that "the convergence of moisture into a storm not only leads to higher precipitation but also, for certain storms, greater intensity and growth." So we can see that a combination of warmer air and water lead to increases in rainfall **beyond** the simple Clausius-Clapeyron relationship.

A good example of that is the unprecedented **60 inches** of rain that fell in 2017 in southeast Texas in Hurricane Harvey. Researchers have concluded that a repeat of rainfall that intense is predicted to happen only once every **9,000 years**. A majority of the rain was caused by Harvey's extremely slow movement. But **multiple** attribution studies conclude that a significant amount of rain can be traced to human-caused warming, with various estimates ranging from **15%** to **20%** to **38%**. Using the term "biblical" to describe Harvey's rainfall, MIT's Kerry Emanuel **calculates** a six-fold increase in the probability of an event of that magnitude since just the late 20th century.

A team investigating extreme rainfall in Hurricane Maria reached a similar conclusion: "[E]xtreme precipitation, like that of Hurricane Maria, has become much more likely in recent years and long-term trends in atmospheric and sea surface temperature are both linked to increased precipitation in Puerto Rico." That **paper** finds the probability of rainfall of Maria's magnitude has increased by a factor of almost five in the most heavily impacted areas.

Does climate change affect the forward speed of hurricanes?

Some climate scientists theorize that slower steering currents resulting from a warmer climate may have contributed to Harvey's lethargic movement. At this point, that question remains unanswered.

But a 2018 study by NOAA's James Kossin **discovered** a 10% global reduction in forward speed of tropical cyclones since 1949. Even more concerning – because of the impact on flooding – is the heightened slowdown detected over land areas: 21% in the western north Pacific and 16% in the North Atlantic. Authors of another **study** support these concerns, finding a significant positive trend over the past several decades in coastal rainfall from tropical cyclones that stall. That study does not, however, reach a conclusion on the reason for the increased stalling.

Will hurricanes become more common in the future?

In a comprehensive 2015 **paper**, lead author Thomas Knutson of NOAA GFDL and co-authors examined a middle-of-the-road warming scenario using computer model simulations. Along with many other **studies**, their projections show a general future decrease in the overall number of tropical cyclones.

This decrease in number of storms is generally believed to be a byproduct of increasing wind shear hostile environmental winds expected in the tropics. But there may be another, more significant reason for the anticipated decrease in storm number.

According to Emanuel of MIT, an increase in saturation deficit of the atmosphere at cloud level is the culprit identified on model simulations. In simpler terms, the saturation deficit just means the atmosphere has a tougher time reaching its capacity of moisture.

While many models do forecast a decrease in number, Emanuel's 2013 **study**, using a higher-end warming scenario, found that the frequency of tropical cyclones increased in most locations. And that study is not alone. A more recent **study** Kieran Bhatia from NOAA GFDL, using the high-resolution HiFLOR model, shows a global increase in storm frequency of 9% and a 23% increase in the Atlantic basin by the end of the 21st century.

When asked about the conflicting research findings on cyclone frequency, Emanuel said by email: "My own view is that we really do not know at this point whether the overall global frequency of [tropical cyclones] will increase, decrease, or stay the same. It is an area of active research."

But Emanuel stresses that the frequency metric is dominated by weak storms that typically do not do much damage, making frequency much less consequential than nailing down future intensity and rainfall.

"There is a strong consensus in the tropical cyclone climate community that the incidence of high-category events will increase, and that storms will precipitate more," Emanuel said.

Will hurricanes become more intense in the future?

According to **NOAA**, 85% of all damages from hurricanes come from category 3, 4, and 5 storms. That's the case in part because of their intense winds. Incredibly, a hurricane with 150-mph wind speed has 256 times the damage potential of a hurricane with 75-mph winds.

In a 2015 **paper** using future model **simulations**, Knutson found an "increase in average cyclone intensity, precipitation rates, and the number and occurrence days of very intense category 4 and 5 storms." Specifically, the simulations calculated a 28% increase in category 4 and 5 storms globally, with a 335% increase in the northeast Pacific and a 42% increase in the North Atlantic.

In Bhatia's 2018 **study**, the intensity gains are even more alarming. The HiFLOR simulations project the number of major cyclones (category 3, 4, and 5) to increase by 20% globally and 29% in the Atlantic by 2081-2100. But HiFLOR suggests a significant increase in major systems even sooner.

The numbers really spike when isolating just category 5 storms, with an 85% global jump and 136% Atlantic basin leap. Of these findings, Bhatia says, "HiFLOR climate change experiments signal that tropical cyclones will more routinely reach wind speeds that are well above the category 5 threshold, hinting that the Saffir Simpson scale might need to be extended to include higher categories in the early 21st century."

How will hurricane rainfall change in the future?

Projections of future rainfall increases in tropical cyclones are also notable. Knutson's study finds a global rain rate increase of 14% by the end of the 21st century.

Emanuel's 2017 **study** of Hurricane Harvey calculates that hurricane rains of 20 inches in Texas will evolve from a once-in-100-year event at the end of the 20th century to a once-in-5.5-year occurrence by 2100. Given that the vast majority of damage from storms like Hurricanes Harvey and Florence come from rainfall, these findings raise concerns.

Will hurricanes intensify more rapidly in the future?

Rapid intensification is one of the least well-predicted tropical cyclone processes and also one of the most dangerous, because storms that intensify quickly tend to catch people off guard. Rapid intensification is another aspect of tropical cyclones characterized by broad agreement among researchers.

Along with various aspects of intensity, the 2018 HiFLOR study "signals that climate change could allow TCs [tropical cyclones] to rapidly intensify over a larger portion of the world's oceans and increase TC intensification rates dramatically."

A **2017 paper** by Kerry Emanuel finds that "the incidence of storms that intensify rapidly just before landfall increases substantially as a result of global warming." To illustrate just how large the changes are, Emanuel quantifies them: "These results suggest that a storm that intensifies 70 mph in the 24 hours just before landfall, occurring on average once per century in the climate of the late twentieth century, may occur every 5-10 years by the end of this century."

Is there a danger to people or property?

Given the expected boost in intense cyclones, society faces growing threats. With a combination of stronger storms, sea-level rise, increased coastal populations, and infrastructure exposure, damages and disruptions will continue to mount.

Since 1970, the global population exposed to tropical cyclone hazards has increased **threefold** a figure expected to continue to increase over the next few decades. Tropical cyclone damages, adjusted for inflation, are **rising** by approximately 6% per year since 1970.

The vast majority of deaths are caused by the most lethal storm systems, and in fact **more than half** of tropical cyclone-related deaths in the U.S. since 1900 have been caused by just three storms. Although those mortality numbers are decreasing because of better warnings and preparation, it is easy to see that a future with more intense storms will cause more serious societal impacts.

Storm surge is one the deadliest aspects of landfalling tropical systems, responsible for nearly **50%** of deaths since 1963. Experts estimate that global sea-level will **rise** between a couple to a few feet by the end of the century. In itself, even without stronger cyclones, sea-level rise will cause exponential damages and exposures.

In a **prophetic paper** published just before Hurricane Sandy, four researchers warned that sea-level rise and changes in storm climatology would increase the risk of disastrous floods in New York City. Specifically, they calculated that a present-day 1-in-100-year flood will occur once every three to 20 years, and a 500-year flood will happen once every 25-240 years by 2100.

A warmer climate will also bring some shifts in storm locations. For example, the authors of a 2014 **paper** discovered that tropical systems increasingly are reaching maximum intensity farther north or south from the

equator as warmer waters expand towards the North and South Poles. In the Atlantic basin, this prospect puts areas of the U.S. northeast coast and maritime Canada in greater danger of a stronger hurricane.

This **recent paper** also forecasts an elevated threat of land-falling tropical cyclones in Taiwan, the Philippines, Hawaii, and the southeastern United States.

Using 21st-century climate model projections, a more recent **study** led by Mingfang Ting of Columbia University concludes that human-caused warming may lead to a weakening of disruptive vertical wind shear during active Atlantic hurricane cycles. Recall that "wind shear" refers to hostile environmental winds that act as a barrier to storms, helping to weaken and sometimes steer storms away from land. If this research pans out, wind shear will be less able to weaken future storms along the U.S. East Coast during periods of heightened hurricane activity.

This weakening of wind shear is likely to result in more rapid intensification of storms as they near landfall. On a massively populated coast with a heavily built environment, this combination will be dangerous and destructive.

Assessing the risk from both wind and storm surge, the author of a 2017 **paper** concludes: "In combination, climate change and coastal development will cause hurricane damage to increase faster than the U.S. economy is expected to grow. In addition, we find that the number of **people** facing substantial expected damage will, on average, increase more than eight-fold over the next 60 years."

It's clear from the research presented above that threats from tropical systems, and in particular from the most intense cyclones, are increasing. This trend will continue for the foreseeable future. Although some of these anticipated impacts are already baked into our warmer climate, the most serious escalations can still be averted. The only remedy is a rapid decarbonization of our economy and a society that is better prepared for threats coming our way.

Jeff Berardelli is a meteorologist and climate contributor to CBS News in New York City.

CLIMATOLOGY

Increased U.S. coastal hurricane risk under climate change

Karthik Balaguru[1]*, Wenwei Xu[1], Chuan-Chieh Chang[1], L. Ruby Leung[1], David R. Judi[1], Samson M. Hagos[1], Michael F. Wehner[2], James P. Kossin[3], Mingfang Ting[4]

Several pathways for how climate change may influence the U.S. coastal hurricane risk have been proposed, but the physical mechanisms and possible connections between various pathways remain unclear. Here, future projections of hurricane activity (1980–2100), downscaled from multiple climate models using a synthetic hurricane model, show an enhanced hurricane frequency for the Gulf and lower East coast regions. The increase in coastal hurricane frequency is driven primarily by changes in steering flow, which can be attributed to the development of an upper-level cyclonic circulation over the western Atlantic. The latter is part of the baroclinic stationary Rossby waves forced mainly by increased diabatic heating in the eastern tropical Pacific, a robust signal across the multimodel ensemble. Last, these heating changes also play a key role in decreasing wind shear near the U.S. coast, further aggravating coastal hurricane risk enhanced by the physically connected steering flow changes.

INTRODUCTION

Hurricanes rank among the leading causes of economic damages in the United States annually (*1*–*3*) with wide-ranging societal impacts upon landfall (*4*, *5*). It is thus of great socioeconomic and scientific interest to understand how the risk associated with hurricanes will evolve in the future climate. As the planet continues to warm, global hurricane risk is expected to rise (*1*, *6*–*11*), because of increases in storm maximum intensity (*11*–*15*), decreases in translation speed (*11*, *16*–*18*), increasing near-center precipitation rate (*19*–*21*), and shifting tracks (*22*). However, examining changes in storm characteristics at global or basin scales can occasionally mask notable regional shifts in climate model simulations, making it difficult to interpret hurricane risk locally. Therefore, besides exploring changes in various aspects of hurricanes on the global scale, a better understanding of how hurricane characteristics will evolve on regional scales is particularly important for assessing future losses resulting from landfalling storms. As indicated by a number of studies, anticipated stalling of storms (*16*–*18*, *23*), increasing hurricane intensification rates (*24*, *25*), and slower dissipation after landfall (*26*) could pose greater hazards to coastal communities in future (*27*). In addition, future growth in population and wealth along the U.S. Gulf and East coasts combined with rising sea levels (*6*, *15*) could further exacerbate the risk associated with landfalling hurricanes (*2*).

Despite this, the physical mechanisms responsible for how anthropogenic climate change will influence certain aspects of hurricanes in the nearshore region are not well understood. For instance, climate models project a robust decrease in vertical wind shear near the U.S. coast (*24*, *25*, *28*, *29*), but the underlying physical rationales have not been firmly established. Similarly, the relative importance of various processes leading to the slowdown of storms (*16*–*18*, *23*) and changes in hurricane landfall (*30*–*34*) remains unclear. Beyond physical understanding, robust quantification of anthropogenic influence on near-coastal hurricane characteristics is difficult to achieve on the basis of observations and dynamical models (*15*, *35*). On average, only one to two hurricanes make landfall each year over the continental United States (*2*), and such limited historical records are not enough to derive meaningful estimates of how the long-term risk posed by the hurricanes may respond to a changing climate (*35*, *36*). General circulation models (GCMs) are the most straightforward approach to assessing the impact of climate change on hurricane risk as they directly simulate hurricane evolution based on physical laws. However, it is computationally expensive to generate a sufficient number of storms for hazard assessment because high spatial resolutions are necessary to realistically simulate the distributions of storm tracks and intensities (*15*, *37*, *38*).

Consequently, statistical-dynamical downscaling methods exploiting the dependence of hurricane climatology on the large-scale storm environment have been developed to generate large ensembles of synthetic hurricane tracks (*35*, *36*, *39*). In this study, we use the Risk Analysis Framework for Tropical Cyclones (RAFT) (*40*), a hybrid modeling approach that combines physics, statistics, and machine learning to produce a large number of synthetic hurricanes, including tracks and along-track intensities (see Materials and Methods and text S1), to understand how the U.S. coastal hurricane risk may change with projected climate change. Subsequently, we use a nonlinear stationary wave model (SWM) (*41*) to uncover the dynamical mechanisms that play a key role in the evolving coastal hurricane risk.

RESULTS

The coastal hurricane frequency (CHF) (*42*), estimated on the basis of RAFT (*40*) and environmental fields from National Centers for Environmental Prediction (NCEP) (*43*) and ECMWF Reanalysis v5 (ERA5) (*44*) (see Materials and Methods), is shown in Fig. 1A over the historical period of 1979–2018. The CHF is defined as the number of 6-hour overland hurricane track locations per square degree per year, where the storm intensity exceeds a threshold

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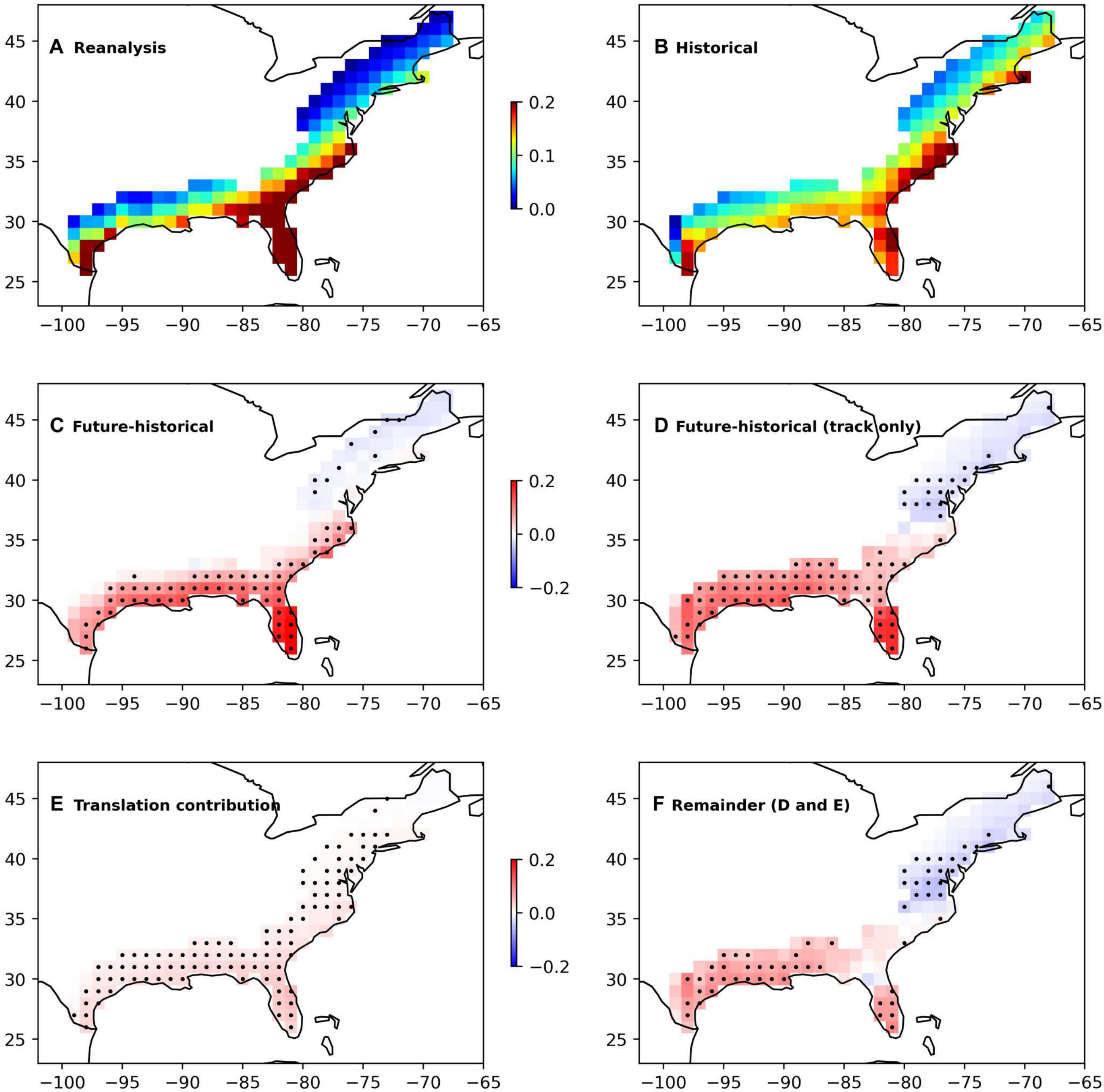

Fig. 1. Projected change in U.S. hurricane risk based on Risk Analysis Framework for Tropical Cyclones (RAFT). (**A**) Climatological coastal hurricane frequency (CHF), defined as the number of 6-hour hurricane track locations per square degree per year, obtained when RAFT is used with reanalysis (1979–2018). All track locations where the storm intensity exceeds 25 knots are used. (**B**) Climatological CHF obtained when RAFT is used with historical phase 6 of the Coupled Model Intercomparison Project (CMIP6) simulations. Ensemble mean of eight models for the historical period 1980–2014 is shown. All track locations where the storm intensity exceeds 21.5 knots are used to estimate CHF. (**C**) Change in CHF for the future period (2066–2100) with respect to the historical period (1980–2014) under the SSP585 emissions scenario. (**D**) As in (C) but based only on the track model in RAFT. A 2-day cutoff is used to truncate tracks over land. (**E**) Change in CHF for the future period based on projected change in translation speed. (**F**) Contribution of projected change in landfall to future change in CHF estimated as the difference between (D) and (E). In (C) to (F), black dots indicate those locations where seven of the eight models agree on the sign of the change.

(see Materials and Methods). The potential threat that hurricanes pose to coastal communities can be assessed using the CHF because it considers the combined effects of hurricane frequency, intensity, track patterns, and translation speeds. As revealed in Fig. 1A, the Gulf Coast and the lower East Coast (south of 40°N) have experienced higher hurricane risk than the upper East Coast (north of 40°N) from 1979 to 2018. Regions that have been particularly vulnerable to hurricanes include the lower East Coast, Florida, and the coasts of Texas and Louisiana (Fig. 1A). Furthermore, CHF simulated with the reanalysis datasets is in reasonable agreement with that obtained using the best-track data (fig. S1A) with a pattern correlation of about 0.7 (significant at the 99% confidence level) and a mean absolute error of about 0.05, demonstrating the ability of RAFT to quantitatively estimate the risk posed by hurricanes for the coastal regions. Next, environmental fields derived from eight climate models belonging to phase 6 of the Coupled Model Intercomparison Project (CMIP6) (*45*) are used with RAFT (see Materials and Methods). The spatial pattern of CHF obtained by applying RAFT to the historical CMIP6 simulations, covering the period 1980–2014, shows broad agreement with that generated using reanalysis (a pattern correlation of 0.85 that is significant at the 99% level and a mean absolute error of about 0.04) as it presents higher CHF along the lower East Coast, over Florida peninsula and near the Texas coast (Fig. 1B). However, some biases in the magnitude are visible. RAFT forced with the environmental fields from CMIP6 simulations tends to underestimate the CHF over Florida peninsula, and the CHF near the upper East Coast is somewhat overestimated during 1980–2014. Despite the discrepancies, many aspects of the observed CHF (fig. S1A) are captured by RAFT during the historical period when combined with the CMIP6 multimodel ensemble.

Now, we consider potential changes in CHF under "SSP585," a future climate scenario in which the planet's radiative forcing is expected to increase by about 8.5 Wm^{-2} at the end of the 21st century (*46*). Changes in CHF for the future period (2066–2100) with respect to the historical period (1980–2014) are positive over much of the Gulf Coast and the lower East Coast (Fig. 1C), with the largest increases projected to occur over the northern Gulf Coast and Florida peninsula. However, for the upper East Coast, the CHF anomalies are weakly negative and largely insignificant. Because changes in the CHF include the joint effects of intensity and steering flow, we next examine the changes in CHF based only on the track model within RAFT to isolate the role of steering flow. The results based on the track model, assuming no change in hurricane intensity (Fig. 1D), suggest that the CHF will likely increase over much of the Gulf Coast, Florida peninsula, and the lower East Coast and decrease near the upper East Coast and are largely consistent with those based on the combined changes of intensity and tracks (Fig. 1C). The similarity between Fig. 1C and Fig. 1D indicates that differences in steering flow are the major drivers for the overall change in CHF. Further decomposing the effects of steering flow (see Materials and Methods) reveals that the contribution from translation speed (Fig. 1E) is notable but weakly positive for most coastal areas. The positive contribution of translation speed to CHF is due to a slowing down or stalling of storms over the US (Fig 2B), which is projected to occur under climate change by some studies (*16*–*18*). Besides translation speed, landfall or a shift in tracks is the other important pathway through which the steering flow affects CHF. Note that the spatiotemporal distribution of genesis is held fixed for both the historical and future periods, in part due to the ambiguity associated with future projections of Atlantic hurricane genesis (see text S1 for further details). Nevertheless, an examination of CHF changes projected by high-resolution climate models points toward potential regional uncertainty associated with results based on RAFT that ignores genesis changes, especially for the lower East Coast (see text S2). Despite the limitations associated with the representation of genesis in RAFT, the framework provides an effective means to isolate the role of steering flow in the evolving hurricane risk. The impact of changes in hurricane track pattern on CHF, obtained as the difference between Fig. 1D and Fig. 1E (see Materials and Methods), suggests that it plays the dominant role. More specifically, the dipole-like spatial pattern of a broad increase in CHF over the Gulf and lower East Coast regions, and a projected decrease in CHF near the upper East Coast, can mainly be attributed to steering flow-induced changes in hurricane tracks. The map of changes in hurricane strike probabilities along the coast (fig. S2) is consistent with this assessment.

Because future changes in CHF projected by RAFT are mainly caused by shifts in tracks, we now explore how the environmental steering flow and its associated large-scale winds will evolve as climate changes. Changes in the multimodel ensemble mean steering flow (Fig. 2A) under the SSP585 scenario reveal that the steering flow is projected to become more easterly near the East Coast and more southeasterly in the Gulf of Mexico. Away from the East Coast, the steering flow will become northeasterly over much of the North Atlantic, especially north of 20°N. At the basin scale, the change in hurricane frequency projected by RAFT (fig. S1D) suggests a large increase over the western Atlantic and a weak decrease over the eastern Atlantic. The increase over the western Atlantic occurs because of two reasons. First, the change in hurricane steering flow shifts tracks westward and closer to the U.S. coast. Second, the westward shift in tracks causes storms to go through a climatologically more favorable environment in the western part of the basin. Consequently, there is a substantial enhancement of hurricane frequency over the western Atlantic that leads to an increase in CHF for the Gulf Coast and lower East Coast regions (Fig. 1C).

Also, these changes in steering flow tend to oppose the climatological steering flow pattern and will decrease the hurricane translation speed in the subtropical North Atlantic and over the continental United States (Fig. 2B). This is consistent with the influence of translation speed on CHF noted earlier (Fig. 1E). In RAFT, the steering flow is defined as a weighted mean of winds at 200 and 850 hPa. Examining changes of winds at different levels separately shows that steering flow changes are dominated by the 200-hPa anomalous easterlies and southeasterlies close to the U.S. coast (Fig. 2C) and by those at 850 hPa away from the U.S. coast in the North Atlantic (Fig. 2D). At 200 hPa, the development of a cyclonic circulation anomaly above the Gulf of Mexico (Fig. 2C) is visible, and the northern branch of the cyclone decelerates the westerlies north of 30°N and may cause a considerable slowdown of storms near the populated coastal regions (*18*, *16*). Changes in 850-hPa winds are northeasterly north of 30°N, and northerly between 20°N and 30°N (Fig. 2D). In addition, the intensifying easterly trades over the Caribbean sea tend to accelerate storm motion over this area, consistent with previous studies (*18*). While these results are based on winds at the 200- and 850-hPa levels, additional

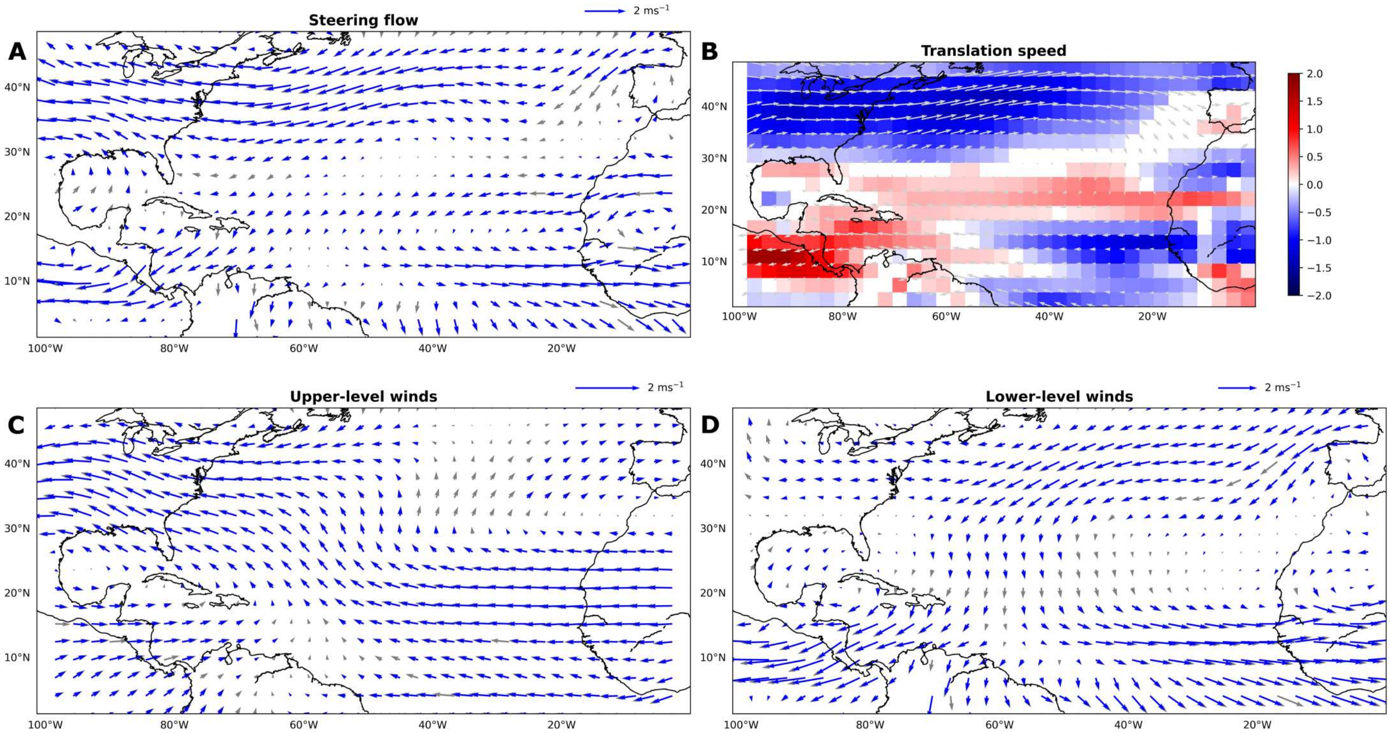

Fig. 2. Projected changes in the environmental steering flow under the SSP585 scenario. (**A**) Vector changes in steering flow. (**B**) Changes in translation speed (shaded) with vectors of climatological steering flow from the historical period overlaid. Vector changes in winds at (**C**) upper level (200 hPa) and (**D**) lower level (850 hPa). Note that the winds at the upper and lower levels are multiplied by 0.2 and 0.8, respectively, to reflect their relevance to the steering flow. Changes are based on the ensemble mean of eight phase 6 of the Coupled Model Intercomparison Project (CMIP6) models. All parameters are averaged over the months of August to October. "Change" indicates the difference between the mean over the future period (2066–2100) and the historical period (1980–2014). In (A), (C), and (D), blue arrows indicate locations where changes in vector magnitude are statistically significant at the 95% level based on the Student's *t* test. In (B), nonwhite shaded areas represent locations where changes in translation speed are significant at the 95% level based on the Student's *t* test.

analysis indicates that they are not sensitive to the exact definition of steering flow used (fig. S3).

Diagnoses using RAFT delineate the dominant role of steering flow in driving the heightened U.S. coastal hurricane risk under a changing climate and motivate us to explore the following important question: What are the underlying dynamical mechanisms responsible for changes in the large-scale hurricane steering flow? Climatological steering flow is principally shaped by geographically fixed low-frequency circulation patterns, such as the subtropical high (*47*), which are an integral part of the stationary waves. These planetary-scale, zonally asymmetric circulation features are relatively stable on the seasonal time scales and arise because of longitudinal asymmetries in topography, diabatic heating, and synoptic eddies (*48*, *49*, *50*). Also, they are influenced by the structure of the background zonal-mean flow (*51*). Here, to better understand the key physical driver in the CMIP6 models, we carry out seven idealized sensitivity experiments with the SWM (table S1). The control run (CTRL) computes deviations from a prescribed zonally symmetric mean state in response to the diabatic heating, transient eddies, and topography in the present (1980–2014) climate. Simulations for the future period (2066–2100) are conducted by applying the basic state and various asymmetric forcings projected by CMIP6 models under the SSP585 emissions scenario as perturbations to the CTRL. The relative contribution of the anomalous basic state, diabatic heating, and transient forcing to the projected total change in circulation is assessed by the following sensitivity runs: CTRL + ΔBS, CTRL + ΔDH, and CTRL + ΔTranF, respectively. In each experiment, only the future input of interest is used and all other inputs are fixed at their historical values. See text S3 for a more detailed description of the model and its validation.

As revealed by the ensemble mean of CMIP6 projections, the tropospheric response to the increasing anthropogenic forcing is characterized by a vertical phase reversal between 10°N and 40°N (Fig. 3, A and B). At 850 hPa, a region of positive streamfunction (ψ) anomaly with anticyclonic flow extends from the Caribbean Sea in the Atlantic to about 120°W in the eastern Pacific, and two anomalous lows are located over the subtropical central Pacific and the eastern North Atlantic (Fig. 3A). The projected lower tropospheric circulation pattern suggests a potential westward shift or expansion of the North Atlantic subtropical high (*52*), which has been regarded to have important implications for the U.S. regional precipitation in a warmer climate (*53*). Meanwhile, the strengthened upper-level cyclonic circulation above the far-eastern North Pacific and the Gulf of Mexico plays a decisive role in steering flow changes near the U.S. coast, as noted earlier (Fig. 2A). When the SWM is subject to simultaneous changes in basic states, diabatic heating, and transient eddies, the spatial pattern of the coupled model's circulation response is qualitatively reproduced at both 850- and 200-hPa levels (Fig. 3, C and D). The magnitude of ψ difference, however, is somewhat overestimated in the model, particularly for the anomalous

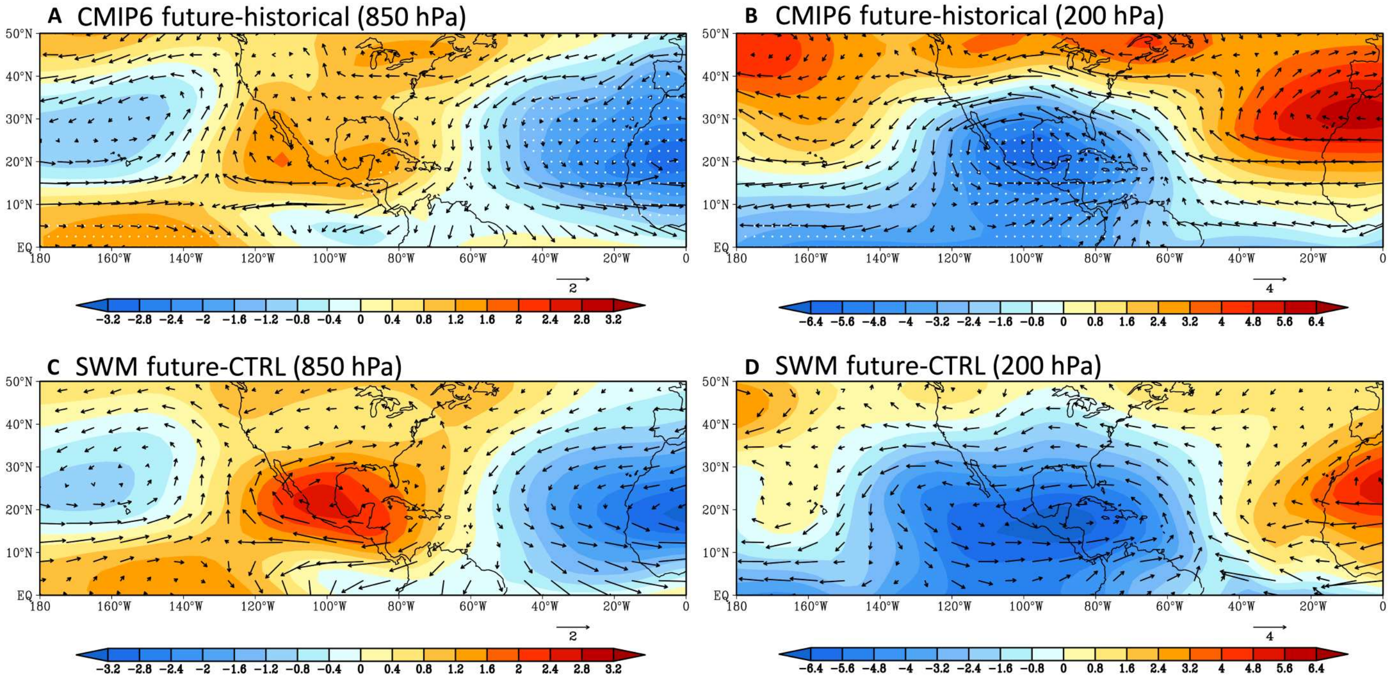

Fig. 3. Changes in the large-scale wind patterns under the SSP585 scenario simulated by the stationary wave model (SWM). Projected changes in streamfunction (shaded, 10^6 m^2s^{-1}) and winds (vector, ms^{-1}) simulated by the ensemble mean of eight phase 6 of the Coupled Model Intercomparison Project (CMIP6) models at (**A**) 850 and (**B**) 200 hPa. In (A) and (B), white stippling denotes the areas where the changes in streamfunction are statistically significant at 95% level based on the Student's *t* test. (**C**) and (**D**) are same as (A) and (B), but for changes simulated by the SWM. All parameters are averaged over the months of August to October. Change indicates the difference between the mean over the future period (2066–2100) and the historical period (1980–2014). EQ, equator.

high centered over the Central American region at 850 hPa (Fig. 3C).

Because the SWM reasonably reproduces the large-scale dynamical response of CMIP6 models to anthropogenic forcing, it allows us to further examine the effect of each forcing mechanism and understand their relative importance. In particular, the primary goal is to understand the physical drivers behind the anomalous 200-hPa cyclonic circulation (Fig. 3B). The changing zonal-mean basic state partially contributes to the increased landfall probability (Fig. 1, D and F) possibly through the enhanced easterlies over the subtropical northwestern Atlantic and the coastal regions of the Gulf of Mexico (Fig. 4A). The weakening of westerly wind occurs over a broad latitude band between 0° and 30°N (Fig. 4A) and is consistent with the poleward shift of the zonal-mean midlatitude jet in the Northern Hemisphere (fig. S4A), which has been robustly projected by various climate models (*18*, *54*, *55*). According to the thermal-wind relationship, such jet response requires a broad warming expansion from the tropics to about 40°N (fig. S4A), and the adiabatic warming in the subtropical mid- and upper troposphere can be further traced back to the enhanced descending motion driven by transient eddies (*54*). On the other hand, the response to the anomalous transient momentum forcing is relatively weak in the SWM (fig. S4B), and both changes in the zonal-mean basic state and transient forcing are unable to explain the enhanced 200-hPa cyclonic winds in a warmer climate (Fig. 3B).

The strengthening of upper tropospheric cyclonic circulation with global warming is primarily caused by changes in diabatic heating (Fig. 4B). Underneath the broad cyclonic circulation, a low-level anticyclonic anomaly forms over the Central American region, which extends over large swaths of the southern United States and into the Atlantic storm-track region. Also, it is worth noting that the easterly trades in the lower troposphere (Fig. 4C), as well as the upper tropospheric westerly winds, intensify (Fig. 4B) in response to variations of tropical heating (Fig. 4D) over the Caribbean Sea. Such flow differences help to explain why several studies (*25*, *28*, *56*) found a secular increase of vertical wind shear over this region in different climate model projections. Furthermore, the baroclinic circulation response (Fig. 4, B and C) excited by the diabatic cooling in the tropical North Atlantic and the positive heating anomalies over the tropical northeastern Pacific (Fig. 4D) is largely consistent with the Gill model's solution (*57*). Previously, it has been proposed that the formation of such a heat-induced stationary baroclinic Rossby wave is mainly reinforced by the anomalous diabatic cooling over the tropical North Atlantic in the late 21st century (*56*). To test this hypothesis, two sensitivity experiments (i.e., CTRL + ΔPacDH and CTRL + ΔAtlDH in table S1) are further carried out. However, our results draw a different conclusion and suggest that the positive heating anomalies over the tropical Pacific sector (fig. S5A) play a dominant role in maintaining the anomalously extensive baroclinic circulation extending from eastern Africa to the northeastern Pacific (fig. S5, B and C), with the secondary contribution coming from the anomalous diabatic cooling over the tropical North Atlantic (fig. S5, D to F). A weaker baroclinic atmospheric response (fig. S5, E and F) is found when the SWM is forced by regional diabatic cooling shown in fig. S5D.

So far, we have seen how future changes in the large-scale winds forced by heating changes in the tropics can affect U.S. hurricanes

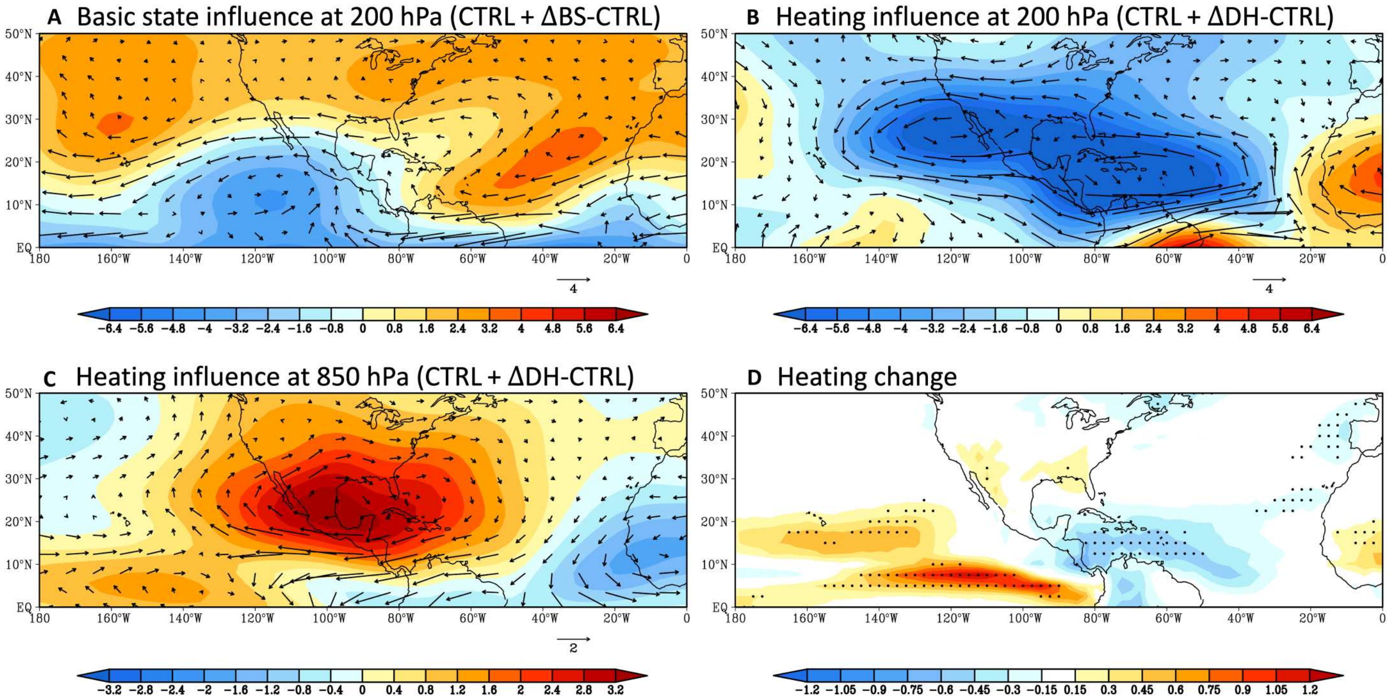

Fig. 4. Understanding changes in the large-scale wind patterns under the SSP585 scenario using the stationary wave model (SWM). (**A**) Contribution from the anomalous zonal-mean basic state to changes in the streamfunction (shaded, 10^6 m^{2}s^{-1}) and winds (vector, ms^{-1}) at 200 hPa. (**B**) Same as (A), but for the contribution from the anomalous zonally asymmetric diabatic heating. (**C**) Same as (B), but at 850 hPa. (**D**) Projected changes in column-averaged pressure-weighted diabatic heating (K day^{-1}). Stippling indicates locations where the ensemble-mean changes are statistically significant at the 95% level. All parameters are averaged over the months of August to October. Change indicates the difference between the mean over the future period (2066–2100) and the historical period (1980–2014). EQ, equator.

and landfall through their influence on steering flow. However, the projected changes of winds at different levels can also affect the vertical wind shear near the U.S. coast. The CMIP6 multimodel ensemble suggests that wind shear will likely reduce near the East Coast of the United States and the northern Gulf of Mexico (Fig. 5A), in line with several previous studies (*24*, *25*, *28*, *29*). When the SWM is forced by simultaneous changes in basic states, diabatic heating, and transient eddies, it broadly reproduces the spatial pattern of wind shear responses over the North Atlantic and the eastern Pacific (Fig. 5B). In particular, the SWM consistently shows a decrease in shear near the East and Gulf coastal regions (Fig. 5B). Further analysis reveals that changes in diabatic heating are primarily responsible for the shear reduction near the coast (Fig. 5C) with the secondary contribution coming from the changing basic state (Fig. 5D). Thus, in addition to altering the steering flow, future changes in diabatic heating could lead to increases in hurricane intensification (*24*, *25*) and tropical cyclogenesis (*34*) near the U.S. coast through the influence on wind shear, highlighting the broad implication of the mechanism identified in this study. Nevertheless, the projected decrease in translation speeds over the subtropical North Atlantic (Fig. 2B) is mainly driven by changes in basic state (fig. S6), which can be likely linked to the poleward shift of the midlatitude westerlies (*18*).

DISCUSSION

Several studies examined shifts in hurricane tracks, at global and regional scales, in observations and future climate projections (*18*, *22*, *30*–*34*). However, considerable uncertainty remains regarding the effect of steering flow changes with some studies favoring an increase in U.S. hurricane landfall (*34*) and others projecting a predominant decrease (*31*, *33*). A physical rationale for the projected changes in steering flow has not been established. In this study, we address this using a suite of numerical simulations based on RAFT and a SWM. With a large number of synthetic tracks simulated by RAFT which overcome the GCM hurricane sampling issue, our results indicate that future changes in steering flow will likely favor an increase in CHF, especially for the Gulf Coast and lower East Coast. Furthermore, changes in the steering flow are mainly driven by the projected strengthening of an upper tropospheric cyclonic circulation above the Gulf of Mexico, which can be regarded as a Gill-type response to the enhanced heating in the eastern tropical Pacific and diabatic cooling over the tropical North Atlantic (Fig. 6). Although simulations based on RAFT project an average increase in CHF of 37 ± 30% for the U.S. Gulf and Atlantic coasts, it must be noted that the use of a time-invariant genesis may introduce some uncertainties in these estimates. A qualitative examination of results based on high-resolution climate models suggests that changes in cyclogenesis may overwhelm the effects of steering flow changes in certain regions (text S2). Therefore, studies that address the ambiguity associated with a shift in genesis are needed to further reduce the uncertainty in our projections of future hurricane risk.

In this study, we have also demonstrated the sensitivity of projected large-scale winds to tropical heating, or precipitation changes, which are largely governed by the spatial pattern of

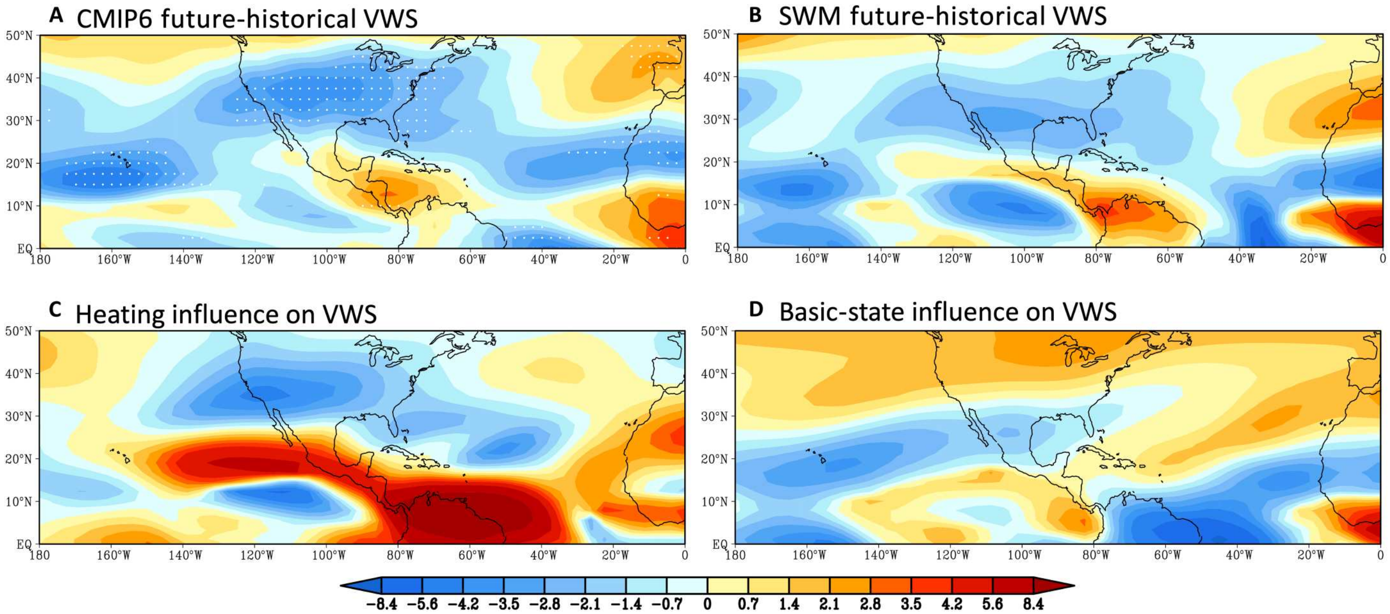

Fig. 5. Understanding changes in vertical wind shear under the SSP585 scenario. (**A**) Projected changes in wind shear (ms^{-1}) by the ensemble mean of eight phase 6 of the Coupled Model Intercomparison Project (CMIP6) models. White stippling denotes the regions where the changes in wind shear are statistically significant at the 95% level. VWS, vertical wind shear. (**B**) is same as (A), but for changes simulated by the SWM. (**C**) Contribution from the anomalous diabatic heating to changes in shear. (**D**) Same as (C), but for contribution from the anomalous zonal-mean basic state. EQ, equator.

future sea surface temperature (SST) warming (*58*–*60*). The physical framework of relative SST warming is mainly built upon thermodynamic considerations. In the tropics, upper tropospheric warming is nearly uniform and approximately follows tropical-mean SST warming (*58*) because temperature gradients are quickly adjusted by equatorial waves (*61*, *62*). In contrast, the moist static energy in the boundary layer is strongly modulated by the local SST (*63*). Enhanced local SST warming therefore leads to a regional destabilization of the atmosphere and favors the occurrence of convective precipitation, enhancing diabatic heating. Correlation analysis indicates that the intermodel uncertainty of projected heating trends over the tropical Pacific and the Maritime continent is strongly constrained by the response of the equatorial Pacific zonal SST gradient to climate change (fig. S7B), suggesting the need to reduce the differences in SST projection (fig. S7A). Some studies suggested a shift toward a more El Niño–like mean state under global warming (*58*). While CMIP5 models show large uncertainty in such SST warming patterns, a strong consensus has emerged in the CMIP6 multimodel ensemble regarding the El Niño–like warming pattern under climate change (*64*), but the differences between the CMIP5 and CMIP6 SST warming patterns are not well understood. Important sources contributing to the uncertainty of future SST warming pattern include large-scale ocean dynamics (*65*, *66*), cloud-radiation feedback (*67*), wind-evaporation SST feedback (*68*), and internal variability associated with the Interdecadal Pacific Oscillation (*64*). A better representation of these physical processes in the climate models and improved observations that can be used to further constrain the parameterized model physics are expected to increase our confidence in future projections of large-scale circulation (*68*). Last, large ensemble simulations also help to better quantify the projected uncertainty associated with internal climate variability.

MATERIALS AND METHODS

Data

Hurricane track data are obtained from the National Hurricane Center's HURDAT2 database and used to compute the CHF. Data for the large-scale hurricane environment are obtained from NCEP reanalysis (*43*) and ERA5 reanalysis (*44*) and used with RAFT to produce synthetic hurricane tracks for the historical period (*40*). First, monthly mean winds at a spatial resolution of 2.5° from NCEP reanalysis are used to generate hurricane steering flow and vertical wind shear. Next, to generate intensity along tracks, potential intensity and other thermodynamic parameters that play a key role in hurricane intensification are estimated on the basis of ERA5 reanalysis, which has a spatial resolution of about 0.3°. This is, in part, due to the smaller spatial scales of thermodynamic parameters like SST and relative humidity compared to dynamical wind fields. The results show that RAFT can well represent the salient features of Atlantic hurricanes, including the spatial distribution of tracks and lifetime maximum intensities (*40*).

Similarly, data for the large-scale environment are obtained from eight fully coupled climate models belonging to CMIP6 (*45*): Canadian Earth System Model (CanESM5), Euro-Mediterranean Centre on Climate Change–coupled climate model (CMCC-CM2-SR5), EC-Earth Consortium Model (EC-Earth3), Geophysical Fluid Dynamics Laboratory Climate Model (GFDLCM4), Institute Pierre Simon Laplace Climate Model (IPSL-CM6A-LR), Model for Interdisciplinary Research on Climate (MIROC6), Max Planck Institute Earth System Model (MPI-ESM1-2-LR), and Meteorological Research Institute Earth System Model (MRI-ESM2-0). The choice of these eight models is based on the availability of data for both the "historical" period and the "future" period under the SSP585 emissions scenario (*46*). A sensitivity analysis has been conducted by computing trends in steering flow and diabatic heating using the

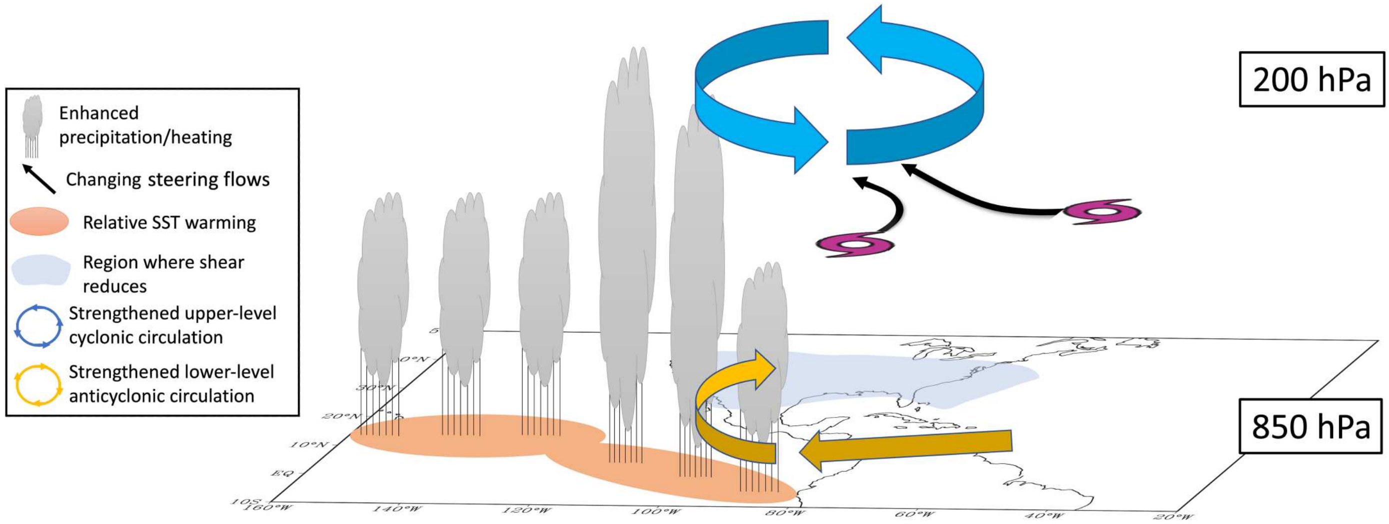

Fig. 6. Schematic illustration of the main mechanisms of coastal hurricane frequency (CHF) changes identified in this study. As the climate warms, an increase in CHF for the U.S. Gulf and lower East coasts is projected to occur and is driven primarily by changes in steering flow. The strengthening upper tropospheric cyclonic circulation above the western Atlantic plays a pivotal role in the steering flow changes. Also, the contrasting upper- and lower-level circulation anomalies reduce the vertical wind shear near the U.S. coastal regions. These changes in circulation can be regarded as a response to the projected increases in diabatic heating and warmer sea surface temperature (SST) over the eastern tropical Pacific, which is a robust signal across the phase 6 of the Coupled Model Intercomparison Project (CMIP6) multimodel ensemble.

SSP585 simulations only and by considering more than 40 CMIP6 models. The results obtained suggest that these eight models are broadly representative of the CMIP6 multimodel ensemble. Last, hurricane tracks from a suite of high-resolution climate model simulations (*69*) belonging to High Resolution Model Intercomparison Project (HighResMIP) (*70*) are used to generate projections of CHF and compare with RAFT (text S2).

Synthetic hurricane model

The RAFT (*40*) is a hybrid modeling approach that can generate large ensembles of hurricanes with realistic spatial track patterns and distributions of intensity. Genesis locations are randomly sampled from a Gaussian spatiotemporal probability distribution based on historical observations (*35*). Tracks are then generated using a "beta-advection" method where a weighted average of winds in the upper (200 hPa) and lower (850 hPa) troposphere are used to guide the forward motion of storms. Subsequently, a deep neural network–based approach is used in RAFT to generate intensity along tracks (*40*). Eleven environmental predictors that play a key role in hurricane intensification (*71*, *40*) are estimated from reanalysis and climate models and used with the intensity component of RAFT to produce hurricane intensity along tracks: current intensity, intensity change in the previous 6 hours, vertical wind shear estimated between 200 and 850 hPa, zonal wind at 200 hPa, maximum potential intensity, latitude, longitude, equivalent potential temperature at 1000 hPa, relative humidity averaged between 700- and 850-hPa levels, zonal component of storm motion, and distance to the nearest major landmass. While an overview of RAFT has been documented previously (*40*), see text S1 for a detailed discussion of how RAFT is combined with CMIP6 models to project hurricane activity into the future.

Stationary wave model

To understand the causes behind the projected changes in steering flow, we use a nonlinear SWM (*41*). Using the SWM, we performed a set of numerical sensitivity experiments to explore the mechanisms responsible for the changes in the large-scale winds and hence the steering flow. The SWM takes the basic state (which includes zonal-mean horizontal winds, air temperature, and surface pressure), diabatic heating, transient fluxes, and orography as inputs to generate the quasi–steady-state large-scale dynamical fields. For further details regarding the SWM, its validation, and the various experiments performed, see text S3 and table S1.

Calculations

The CHF is estimated as the number of 6-hour overland hurricane track locations per square degree per year. All storm locations where the intensity exceeds a threshold are considered in this calculation. In the track model of RAFT, we use a 2-day cutoff to truncate tracks over land. Furthermore, at the end of the 2-day period following landfall, storms reach an intensity of about 25 knots on average in observations (*72*). On the basis of the method of quantile mapping (*73*), a 25-knot threshold in observations translates to 21.5 knots when RAFT is used with CMIP6 models. Thus, to ensure consistency between CHF estimates based on the track model, and those based on including the intensity model along with the track model, we use a threshold of 25 knots for RAFT when used with reanalysis and a threshold of 21.5 knots when RAFT is used with CMIP6 models. However, note that our main conclusions are not very sensitive to the threshold and similar results are obtained using a 1-day cutoff.

Changes in steering flow cause changes in CHF primarily through translation speed and landfall, especially in the region close to the coast. To separate the contribution of changes in storm translation speed and landfall to the total CHF change,

consider the following equation

$$\mathrm{CHF}_{\mathrm{hist}} = n_{\mathrm{hist}} \frac{l}{\text{time step} * v_{\mathrm{hist}}} \tag{1}$$

Here, n is the number of hurricane tracks passing through a grid, l is the grid length, v is the translation speed, and "time step" is 6 hours. The subscript "hist" indicates the historical period. In other words, the equation indicates that the CHF varies directly with the number of storms passing through a region and inversely with the translation speed of storms in that region. Similarly, for the future period, one can write the equation as

$$\mathrm{CHF}_{\mathrm{future}} = n_{\mathrm{future}} \frac{l}{\text{time step} * v_{\mathrm{future}}} \tag{2}$$

To isolate the role of translation, let us assume a scenario with no change in the number of hurricanes passing through a grid. Then, the CHF for the future period ($\mathrm{CHF}_{\mathrm{future}}$) can be expressed as the sum of the CHF for the historical period ($\mathrm{CHF}_{\mathrm{hist}}$) and the effect of translation speed change on CHF ($\mathrm{CHF}_{\mathrm{trans}}$). Now, combining Eqs. 1 and 2, we get

$$\frac{\mathrm{CHF}_{\mathrm{hist}} + \mathrm{CHF}_{\mathrm{trans}}}{\mathrm{CHF}_{\mathrm{hist}}} = \frac{v_{\mathrm{hist}}}{v_{\mathrm{future}}} \tag{3}$$

From this, $\mathrm{CHF}_{\mathrm{trans}}$ can be calculated as

$$\mathrm{CHF}_{\mathrm{trans}} = \mathrm{CHF}_{\mathrm{hist}} \left(\frac{v_{\mathrm{hist}}}{v_{\mathrm{future}}} - 1 \right) \tag{4}$$

Last, the effect of landfall change on CHF ($\mathrm{CHF}_{\mathrm{land}}$) can be estimated as

$$\mathrm{CHF}_{\mathrm{land}} = \mathrm{CHF}_{\mathrm{future}} - \mathrm{CHF}_{\mathrm{hist}} - \mathrm{CHF}_{\mathrm{trans}} \tag{5}$$

Supplementary Materials

This PDF file includes:

Texts S1 to S3
Figs. S1 to S10
Table S1
References

REFERENCES AND NOTES

1. J. Weinkle, C. Landsea, D. Collins, R. Musulin, R. P. Crompton, P. J. Klotzbach, R. Pielke, Normalized hurricane damage in the continental United States 1900–2017. *Nat. Sustain.* **1**, 808–813 (2018).
2. P. J. Klotzbach, S. G. Bowen, R. Pielke, M. Bell, Continental U.S. hurricane landfall frequency and associated damage: Observations and future risks. *Bull. Am. Meteorol. Soc.* **99**, 1359–1376 (2018).
3. A. Grinsted, P. Ditlevsen, J. H. Christensen, Normalized US hurricane damage estimates using area of total destruction, 1900-2018. *Proc. Natl. Acad. Sci. U.S.A.* **116**, 23942–23946 (2019).
4. J. S. Petterson, L. D. Stanley, E. Glazier, J. Philipp, A preliminary assessment of social and economic impacts associated with Hurricane Katrina. *Am. Anthropol.* **108**, 643–670 (2006).
5. J. B. Halverson, T. Rabenhorst, Hurricane Sandy: The science and impacts of a superstorm. *Weatherwise* **66**, 14–23 (2013).
6. J. D. Woodruff, J. L. Irish, S. J. Camargo, Coastal flooding by tropical cyclones and sea-level rise. *Nature* **504**, 44–52 (2013).
7. C. M. Little, R. M. Horton, R. E. Kopp, M. Oppenheimer, G. A. Vecchi, G. Villarini, Joint projections of US East Coast sea level and storm surge. *Nat. Clim. Change* **5**, 1114–1120 (2015).
8. T. Dinan, Projected increases in hurricane damage in the United States: The role of climate change and coastal development. *Ecol. Econ.* **138**, 186–198 (2017).
9. A. Gori, N. Lin, D. Xi, K. Emanuel, Tropical cyclone climatology change greatly exacerbates US extreme rainfall–surge hazard. *Nat. Clim. Change* **12**, 171–178 (2022).
10. T. Knutson, J. C. Suzana, J. C. L. Chan, K. Emanuel, C.-H. Ho, K. James, K. Mohapatra, M. Satoh, M. Sugi, K. Walsh, L. Wu, Tropical cyclones and climate change assessment: Part II: Projected response to anthropogenic warming. *Bull. Am. Meteorol. Soc.* **101**, E303–E322 (2020).
11. K. Emanuel, Response of global tropical cyclone activity to increasing CO_2: Results from downscaling CMIP6 models. *J. Climate* **37**, 57–70 (2020).
12. K. Emanuel, Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* **436**, 686–688 (2005).
13. M. A. Bender, T. R. Knutson, R. E. Tuleya, J. J. Sirutis, G. A. Vecchi, S. T. Garner, I. M. Held, Modeled impact of anthropogenic warming on the frequency of intense atlantic hurricanes. *Science* **327**, 454–458 (2010).
14. A. H. Sobel, S. J. Camargo, T. M. Hall, C.-Y. Lee, M. K. Tippett, A. A. Wing, Human influence on tropical cyclone intensity. *Science* **353**, 242–246 (2016).
15. K. Walsh, S. J. Camargo, T. Knutson, J. Kossin, T.-C. Lee, H. MuraKami, C. Patricola, Tropical cyclones and climate change. *Trop. Cyclone Res. Rev.* **8**, 240–250 (2019).
16. J. P. Kossin, A global slowdown of tropical-cyclone translation speed. *Nature* **558**, 104–107 (2018).
17. J. P. Kossin, Reply to: Moon, I.-J. et al.; Lanzante, J.R. *Nature* **570**, E16–E22 (2019).
18. G. Zhang, H. Murakami, T. R. Knutson, R. Mizuta, K. Yoshida, Tropical cyclone motion in a changing climate. *Sci. Adv.* **6**, eaaz7610 (2020).
19. D. B. Wright, T. R. Knutson, J. A. Smith, Regional climate model projections of rainfall from U.S. landfalling tropical cyclones. *Clim. Dyn.* **45**, 3365–3379 (2015).
20. C. M. Patricola, M. F. Wehner, Anthropogenic influences on major tropical cyclone events. *Nature* **563**, 339–346 (2018).
21. O. Guzman, H. Jiang, Global increase in tropical cyclone rain rate. *Nat. Commun.* **12**, 5344 (2021).
22. S. Wang, R. Toumi, Recent migration of tropical cyclones toward coasts. *Science* **371**, 514–517 (2021).
23. T. M. Hall, J. P. Kossin, Hurricane stalling along the North American coast and implications for rainfall. *npj Clim. Atmos. Sci.* **2**, 17 (2019).
24. K. Balaguru, G. R. Foltz, L. R. Leung, W. Xu, D. Kim, H. Lopez, R. West, Increasing hurricane intensification rate near the US Atlantic coast. *Geophys. Res. Lett.* **49**, e2022GL099793 (2022).
25. M. Ting, J. P. Kossin, S. J. Camargo, C. Li, Past and future hurricane intensity change along the U.S. East coast. *Sci. Rep.* **9**, 7795 (2019).
26. L. Li, P. Chakraborty, Slower decay of landfalling hurricanes in a warming world. *Nature* **587**, 230–234 (2020).
27. S. J. Camargo, A. A. Wing, Increased tropical cyclone risk to coasts. *Science* **371**, 458–459 (2021).
28. G. A. Vecchi, B. J. Soden, Increased tropical atlantic wind shear in model projections of global warming. *Geophys. Res. Lett.* **34**, L08702 (2007).
29. J. P. Kossin, Hurricane intensification along United States coast suppressed during active hurricane periods. *Nature* **541**, 390–393 (2017).
30. J. P. Kossin, S. J. Camargo, M. Sitkowski, Climate modulation of North Atlantic hurricane tracks. *J. Climate* **23**, 3057–3076 (2010).
31. A. J. Colbert, B. J. Soden, G. A. Vecchi, B. P. Kirtman, The impact of anthropogenic climate change on North Atlantic tropical cyclone tracks. *J. Climate* **26**, 4088–4095 (2013).
32. A. J. Garner, R. E. Kopp, B. P. Horton, Evolving tropical cyclone tracks in the North Atlantic in a warming climate. *Earth's Future* **9**, e2021EF002326 (2021).
33. T. M. Hall, J. P. Kossin, T. Thompson, J. McMahon, U.S. tropical cyclone activity in the 2030s based on projected changes in tropical sea surface temperature. *J. Climate* **34**, 1321–1335 (2021).
34. T. R. Knutson, J. J. Sirutis, M. A. Bender, R. E. Tuleya, B. A. Schenkel, Dynamical downscaling projections of late twenty-first-century U.S. landfalling hurricane activity. *Clim. Change* **171**, 28 (2022).
35. K. Emanuel, S. Ravela, E. Vivant, C. Risi, A statistical deterministic approach to hurricane risk assessment. *Bull. Am. Meteorol. Soc.* **87**, 299–314 (2006).
36. C.-Y. Lee, M. K. Tippett, A. H. Sobel, S. J. Camargo, An environmentally forced tropical cyclone hazard model. *J. Adv. Model. Earth Syst.* **10**, 223–241 (2018).
37. J. V. Manganello, K. I. Hodges, J. L. K. III, B. A. Cash, L. Marx, T. Jung, D. Achuthavarier, J. M. Adams, E. L. Altshuler, B. Huang, E. K. Jin, C. Stan, P. Towers, N. Wedi, Tropical cyclone climatology in a 10-km global atmospheric GCM: Toward weather-resolving climate modeling. *J. Climate* **25**, 3867–3893 (2012).
38. S. J. Camargo, A. A. Wing, Tropical cyclones in climate models. *WIREs Clim. Change* **7**, 211–237 (2016).

39. N. Bloemendaal, I. D. Haigh, H. de Moel, S. Muis, R. J. Haarsma, J. C. J. H. Aerts, Generation of a global synthetic tropical cyclone hazard dataset using STORM. *Sci. Data* **7**, 40 (2020).
40. W. Xu, K. Balaguru, A. August, N. Lalo, N. Hodas, M. DeMaria, D. Judi, Deep learning experiments for tropical cyclone intensity forecasts. *Weather Forecast.* **36**, 1453–1470 (2021).
41. M. Ting, L. Yu, Steady response to tropical heating in wavy linear and nonlinear baroclinic models. *J. Atmos. Sci.* **55**, 3565–3582 (1998).
42. H. Murakami, T. L. Delworth, W. F. Cooke, M. Zhao, B. Xiang, P.-C. Hsu, Detected climatic change in global distribution of tropical cyclones. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 10706–10714 (2020).
43. E. Kalnay, M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, A. Leetmaa, R. Reynolds, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, R. Jenne, D. Joseph, The NCEP/NCAR 40-year reanalysis project. *Bull. Am. Meteorol. Soc.* **77**, 437–471 (1996).
44. H. Hersbach, B. Bell, P. Berrisford, S. Hirahara, A. Horányi, J. Muñoz-Sabater, J. Nicolas, C. Peubey, R. Radu, D. Schepers, A. Simmons, C. Soci, S. Abdalla, X. Abellan, G. Balsamo, P. Bechtold, G. Biavati, J. Bidlot, M. Bonavita, G. Chiara, P. Dahlgren, D. Dee, M. Diamantakis, R. Dragani, J. Flemming, R. Forbes, M. Fuentes, A. Geer, L. Haimberger, S. Healy, R. J. Hogan, E. Hólm, M. Janisková, S. Keeley, P. Laloyaux, P. Lopez, C. Lupu, G. Radnoti, P. Rosnay, I. Rozum, F. Vamborg, S. Villaume, J.-N. Thépaut, The ERA5 global reanalysis. *Q. J. Roy. Meteorol. Soc.* **146**, 1999–2049 (2020).
45. V. Eyring, S. Bony, G. A. Meehl, C. A. Senior, B. Stevens, R. J. Stouffer, K. E. Taylor, Overview of the Coupled Model Intercomparison Project phase 6 (CMIP6) experimental design and organization. *Geosci. Model Dev.* **9**, 1937–1958 (2016).
46. B. C. O'Neill, C. Tebaldi, D. P. Van Vuuren, V. Eyring, P. Friedlingstein, G. Hurtt, R. Knutti, E. Kriegler, J.-F. Lamarque, J. Lowe, G. A. Meehl, R. Moss, K. Riahi, B. M. Sanderson, The scenario model intercomparison project (scenarioMIP) for CMIP6. *Geosci. Model Dev.* **9**, 3461–3482 (2016).
47. B. Wang, B. Xiang, J.-Y. Lee, Subtropical high predictability establishes a promising way for monsoon and tropical storm predictions. *Proc. Natl. Acad. Sci. U.S.A.* **110**, 2718–2722 (2013).
48. A. J. Simmons, The forcing of stationary wave motion by tropical diabatic heating. *Q. J. Roy. Meteorol. Soc.* **108**, 503–534 (1982).
49. B. J. Hoskins, D. J. Karoly, The steady linear response of a spherical atmosphere to thermal and orographic forcing. *J. Atmos. Sci.* **38**, 1179–1196 (1981).
50. S. Manabe, T. B. Terpstra, The effects of mountains on the general circulation of the atmosphere as identified by numerical experiments. *J. Atmos. Sci.* **31**, 3–42 (1974).
51. I. M. Held, M. Ting, H. Wang, Northern winter stationary waves: Theory and modeling. *J. Climate* **15**, 2125–2144 (2002).
52. W. Li, L. Li, M. Ting, Y. Liu, Intensification of northern hemisphere subtropical highs in a warming climate. *Nat. Geosci.* **5**, 830–834 (2012).
53. F. Song, L. R. Leung, J. Lu, L. Dong, Future changes in seasonality of the North Pacific and North Atlantic subtropical highs. *Geophys. Res. Lett.* **45**, 11959–11968 (2018).
54. Y. Wu, R. Seager, M. Ting, N. Naik, T. A. Shaw, Atmospheric circulation response to an instantaneous doubling of carbon dioxide. Part I: Model experiments and transient thermal response in the troposphere. *J. Clim.* **25**, 2862–2879 (2012).
55. E. A. Barnes, L. Polvani, Response of the midlatitude jets, and of their variability, to increased greenhouse gases in the CMIP5 models. *J. Climate* **26**, 7117–7135 (2013).
56. S.-K. Lee, D. B. Enfield, C. Wang, Future impact of differential interbasin ocean warming on Atlantic hurricanes. *J. Climate* **24**, 1264–1275 (2011).
57. A. E. Gill, Some simple solutions for heat-induced tropical circulation. *Q. J. Roy. Meteorol. Soc.* **106**, 447–462 (1980).
58. S.-P. Xie, C. Deser, G. A. Vecchi, J. Ma, H. Teng, A. T. Wittenberg, Global warming pattern formation: Sea surface temperature and rainfall. *J. Climate* **23**, 966–986 (2010).
59. R. Chadwick, P. Good, T. Andrews, G. Martin, Surface warming patterns drive tropical rainfall pattern responses to CO_2 forcing on all timescales. *Geophys. Res. Lett.* **41**, 610–615 (2014).
60. C. Kent, R. Chadwick, D. P. Rowell, Understanding uncertainties in future projections of seasonal tropical precipitation. *J. Climate* **28**, 4390–4413 (2015).
61. A. H. Sobel, J. Nilsson, L. M. Polvani, The weak temperature gradient approximation and balanced tropical moisture waves. *J. Atmos. Sci.* **58**, 3650–3665 (2001).
62. C. S. Bretherton, A. H. Sobel, A simple model of a convectively coupled walker circulation using the weak temperature gradient approximation. *J. Climate* **15**, 2907–2920 (2002).
63. D. J. Raymond, Regulation of moist convection over the west Pacific warm pool. *J Atmos. Sci.* **52**, 3945–3959 (1995).
64. L. Dong, L. R. Leung, F. Song, J. Lu, Uncertainty in El Niño-like warming and California precipitation changes linked by the interdecadal Pacific oscillation. *Nat. Commun.* **12**, 6484 (2021).
65. R. Seager, M. Cane, N. Henderson, D.-E. Lee, R. Abernathey, H. Zhang, Strengthening tropical Pacific zonal sea surface temperature gradient consistent with rising greenhouse gases. *Nat. Clim. Change* **9**, 517–522 (2019).
66. J. Ying, P. Huang, The large-scale ocean dynamical effect on uncertainty in the tropical Pacific SST warming pattern in CMIP5 models. *J. Climate* **29**, 8051–8065 (2016).
67. J. Ying, P. Huang, Cloud–radiation feedback as a leading source of uncertainty in the tropical Pacific SST warming pattern in CMIP5 models. *J. Climate* **29**, 3867–3881 (2016).
68. J. Ma, S.-P. Xie, Regional patterns of sea surface temperature change: A source of uncertainty in future projections of precipitation and atmospheric circulation. *J. Climate* **26**, 2482–2501 (2013).
69. M. Roberts, CMIP6 HighResMIP: Tropical storm tracks as calculated by the TempestExtremes algorithm (Centre for Environmental Data Analysis, 2019).
70. R. J. Haarsma, M. J. Roberts, P. L. Vidale, C. A. Senior, A. Bellucci, Q. Bao, P. Chang, S. Corti, N. S. Fučkar, V. Guemas, J. von Hardenberg, W. Hazeleger, C. Kodama, T. Koenigk, L. R. Leung, J. Lu, J.-J. Luo, J. Mao, M. S. Mizielinski, R. Mizuta, P. Nobre, M. Satoh, E. Scoccimarro, T. Semmler, J. Small, J.-S. von Storch, High resolution model intercomparison project (HighResMIP v1.0) for CMIP6. *Geosci. Model Dev.* **9**, 4185–4208 (2016).
71. M. DeMaria, M. Mainelli, L. K. Shay, J. A. Knaff, J. Kaplan, Further improvements to the statistical hurricane intensity prediction scheme (ships). *Weather Forecast.* **20**, 531–543 (2005).
72. J. Kaplan, M. DeMaria, A simple empirical model for predicting the decay of tropical cyclone winds after landfall. *J. Appl. Meteorol. Climatol.* **34**, 2499–2512 (1995).
73. A. J. Cannon, S. R. Sobie, T. Q. Murdock, Bias correction of GCM precipitation by quantile mapping: How well do methods preserve changes in quantiles and extremes? *J. Climate* **28**, 6938–6959 (2015).
74. A. H. Sobel, A. A. Wing, S. J. Camargo, C. M. Patricola, G. A. Vecchi, C.-Y. Lee, M. K. Tippett, Tropical cyclone frequency. *Earth's Future* **9**, e2021EF002275 (2021).
75. H. Murakami, B. Wang, Patterns and frequency of projected future tropical cyclone genesis are governed by dynamic effects. *Commun. Earth Environ.* **3**, 77 (2022).
76. L. Wu, B. Wang, Assessing impacts of global warming on tropical cyclone tracks. *J. Climate* **17**, 1686–1698 (2004).
77. P. Kelly, L. R. Leung, K. Balaguru, W. Xu, B. Mapes, B. Soden, Shape of Atlantic tropical cyclone tracks and the Indian monsoon. *Geophys. Res. Lett.* **45**, 10–746 (2018).
78. P. A. Ullrich, C. M. Zarzycki, E. E. McClenny, M. C. Pinheiro, A. M. Stansfield, K. A. Reed, TempestExtremes v2.1: A community framework for feature detection, tracking, and analysis in large datasets. *Geosci. Model Dev.* **14**, 5023–5048 (2021).
79. T. R. Knutson, J. J. Sirutis, S. T. Garner, G. A. Vecchi, I. M. Held, Simulated reduction in Atlantic hurricane frequency under twenty-first-century warming conditions. *Nat. Geosci.* **1**, 359–364 (2008).
80. K. Yoshida, M. Sugi, R. Mizuta, H. Murakami, M. Ishii, Future changes in tropical cyclone activity in high-resolution large-ensemble simulations. *Geophys. Res. Lett.* **44**, 9910–9917 (2017).
81. A. S. Daloz, S. J. Camargo, Is the poleward migration of tropical cyclone maximum intensity associated with a poleward migration of tropical cyclone genesis? *Climate Dynam.* **50**, 705–715 (2018).
82. M. F. Wehner, K. A. Reed, B. Loring, D. Stone, H. Krishnan, Changes in tropical cyclones under stabilized 1.5 and 2.0°C global warming scenarios as simulated by the Community Atmospheric Model under the HAPPI protocols. *Earth Syst. Dyn.* **9**, 187–195 (2018).
83. G. Zhang, L. G. Silvers, M. Zhao, T. R. Knutson, Idealized aquaplanet simulations of tropical cyclone activity: Significance of temperature gradients, Hadley circulation, and zonal asymmetry. *J. Atmos. Sci.* **78**, 877–902 (2021).
84. J. Studholme, A. V. Fedorov, S. K. Gulev, K. Emanuel, K. Hodges, Poleward expansion of tropical cyclone latitudes in warming climates. *Nat. Geosci.* **15**, 14–28 (2022).
85. K. Emanuel, Response of global tropical cyclone activity to increasing CO_2: Results from downscaling CMIP6 models. *J. Climate* **34**, 57–70 (2021).
86. I. R. Simpson, R. Seager, M. Ting, T. A. Shaw, Causes of change in Northern Hemisphere winter meridional winds and regional hydroclimate. *Nat. Clim. Change* **6**, 65–70 (2016).
87. B. Hoskins, On the existence and strength of the summer subtropical anticyclones: Bernhard Haurwitz memorial lecture. *Bull. Am. Meteorol. Soc.* **77**, 1287–1292 (1996).
88. S. Nigam, C. Chung, E. DeWeaver, ENSO diabatic heating in ECMWF and NCEP–NCAR reanalyses, and NCAR CCM3 simulation. *J. Climate* **13**, 3152–3171 (2000).
89. A. Cherchi, H. Annamalai, S. Masina, A. Navarra, South Asian summer monsoon and the Eastern Mediterranean climate: The monsoon-desert mechanism in CMIP5 simulations. *J. Climate* **27**, 6877–6903 (2014).

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From: Kautz, Lance
To: Grave de Peralta, Diego
Cc: Sardinas, Evelyn; D"Abreu, Gordon
Subject: FW: Riverview 5-Day Follow Up Report
Date: Wednesday, October 16, 2024 7:56:28 AM
Attachments: image001.png
image002.png

From: Ford, Dara <Dara.Ford@mosaicco.com>
Sent: Tuesday, October 15, 2024 5:53 PM
To: Kautz, Lance <Lance.Kautz@FloridaDEP.gov>
Cc: Provenzano, Santino <Santino.Provenzano@mosaicco.com>; Figueroa, Veronica <Veronica.Figueroa@mosaicco.com>; Coates, John <John.Coates@FloridaDEP.gov>; Knoll, Matthew <Matthew.Knoll@dep.state.fl.us>; Koplin, Ben <Ben.Koplin@mosaicco.com>
Subject: Riverview 5-Day Follow Up Report

Mr. Kautz,

This correspondence serves as the 5 day follow up to Mosaic's verbal notification provided to the Department on Thursday, October 10^{th} at approximately 11:00 AM.

At 10:30 am on October 10, 2024, Mosaic personnel discovered that two collection manways associated with the Closed West Phosphogypsum Stack seepage collection system were damaged during Hurricane Milton. The damaged manways allowed the commingling of water from the seepage collection system with large volumes of rainfall associated with the heavy rainbands encountered during the passage of the core of the storm - rainfall amounts estimated to be in excess of 12 inches. The commingled seepage water and rainfall, sampled after the storm and found to have a pH of 5.3 SU, overtopped an adjacent roadway and discharged into Hillsborough Bay. A sample collected in Hillsborough Bay in the vicinity of the location of the sheet flow over the roadway was 7.49 SU.

Mosaic stopped the discharge at approximately 2:00 pm on October 10, 2024, and after installing a coffer dam and pump system, began diverting the commingled water back to the facility process water system. The State Watch Office (#2024-9043) was notified. After initial reporting, based on observations in the field, the final discharge volume has been estimated at approximately 39,600 gallons of seepage water commingled with an unquantifiable volume of rainwater. The NRC was also contacted, however Mosaic was informed that only the State Watch Office required notification.

As reported to the agencies, and supported by the field readings collected in the adjacent receiving waters in Hillsborough Bay, there was no visual evidence of impact observed and no injuries due to this discharge.

Please contact me if you have any questions. Below is a copy of the pollution notice for your reference.

Dara Ford

Dara Ford | Sr. Environmental Advisor
Mosaic Fertilizer, LLC | 13830 Circa Crossing Drive | Lithia, Florida 33547
C: 863.860.0989 | F: 863.844.5451 | E: dara.ford@mosaicco.com | W: www.mosaicco.com

From: no-reply@dep.state.fl.us <no-reply@dep.state.fl.us>
Sent: Thursday, October 10, 2024 8:34 PM
To: Ford, Dara - New Wales <Dara.Ford@mosaicco.com>
Subject: Public Notice of Pollution - Initial Notice Received

FLORIDA DEPARTMENT OF
Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Shawn Hamilton
Secretary

Pollution Notice

Pursuant to Section 403.077, F.S., the Department of Environmental Protection has received the following Public Notice of Pollution for a reportable release. All information displayed was submitted by the reporting party.

Type of Notice: Initial Report
Date of Notice: 10/10/2024

Incident Information
Name of Incident: Riverview Impacted Stormwater Release
State Watch Office Case Number:
Start of Incident: 10/10/2024 02:00 AM
End of Incident: 10/10/2024 02:00 PM

Incident Description
An indeterminate volume of impacted stormwater released offsite in connection with Hurricane Milton.

Incident Location
Facility/Installation Name: Mosaic Fertilizer LLC - Riverview Facility
Address Line 1: 8813 US Hwy 41 South
Address Line 2:
Directions:
City: Riverview
State: FL
Zip Code: 33578
Coordinates (in decimal degrees):
Lat: 27.868, Long: -82.401
Click to view Incident Location
Impacted Counties: Hillsborough
Updated Impact:

Incident Reported By
Name: Dara Ford

Title: Sr. Environmental Advisor
Phone: (863) 860-0989
Ext:
E-mail Address: dara.ford@mosaicco.com
Relationship: Sr. Environmental Advisor

On-Site Contact
Name: Jackie Barron
Phone: (941) 322-6811
Ext:
E-mail Address: jackie.barron@mosaicco.com

To view a list of all received Public Notices of Pollution or to modify your e-mail subscription settings, please click the link below:
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Florida Department of Environmental Protection

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Evaluation and Synthesis of Health Effects Studies of Communities Surrounding Arsenic Producing Industries

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Hughes J P (Department of Biostatistics, School of Public Health and Community Medicine, University of Washington SC-32, Seattle WA 98195, USA), Polissar L and van Belle G. Evaluation and synthesis of health effects of communities surrounding arsenic producing industries. *International Journal of Epidemiology* 1988, 17: 407–413.

Epidemiological studies designed to detect lung cancer risk and other health effects in communities surrounding arsenic-producing copper smelters were reviewed. The studies were about evenly divided in finding deleterious and 'beneficial' effects of arsenic. All of the studies had insufficient statistical power to detect the small increases in risk that may occur. Even the most powerful studies were not designed to detect relative risks less than about 1.2 and the majority of the studies had little power to detect risks under 2.0. Confidence intervals for the relative risks from these studies were not very useful in putting an upper bound on adverse effects of arsenic. Sources of bias and other difficulties with community health studies are also discussed. We argue that these studies may be a good and economical first investigation but, due to a lack of power, null findings do not rule out the possibility of excess risks that may be significant from a public health viewpoint.

Several authors[1–5] have noted an association between chronic exposure to high levels of inorganic arsenic and lung cancer in occupationally exposed persons. Copper smelter workers are the principal group at risk but employees in pesticide factories and chemical plants may also be exposed to excessive levels of arsenic. Smelter workers also have an increased risk of heart disease.[5]

In light of these findings, numerous investigators have examined communities surrounding copper smelters[6–17] and a former pesticide plant[18] for evidence of similar adverse health effects among the community population. In only a few instances[6,9,10,16,18] were adverse health effects found in these communities. Even these 'significant' results are questionable: in two[6,16] smelter workers were not excluded from the analysis (in Pershagen[16] the difference was no longer significant when smelter workers were accounted for); in another[9] the statistically significant decrease in birthweight is so small that it may be clinically insignificant or due to other factors that have not been accounted for.

The usual interpretation of these non-significant results is that the relatively low exposure to arsenic in communities surrounding arsenic-emitting industries does not present an increased risk of adverse health effects. However, such a conclusion is unjustified when the studies lack adequate statistical power to detect a difference in the health of exposed and unexposed groups even if a difference truly exists.

Among smelter workers, increases in the relative risk of lung cancer on the order of 2.5[1] to 5.0[5] have been reported. In a community surrounding a smelter the exposure is much lower; consequently, one would expect a much smaller increase in risk. Nevertheless, an increase in the risk of lung cancer, even as small as 10% (ie relative risk = 1.1), should lead to excess mortality in the community. For instance, in a city of 500 000 with lung cancer mortality of 20/100 000 per year, an increase in risk of 10% means an average of 10 additional deaths annually. Thus, a community study of lung cancer would have to be designed to detect very small increases in risk before negative finding can validly be interpreted as evidence of no effect.

In this paper, we review 12 studies of health effects in communities surrounding arsenic-producing industries. First, we discuss the statistical methodology used in the studies[6–18] and methods of determining the minimum detectable risk (MDR)—the minimum change in

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risk that could be detected given the study design and the significance levels used. Results are presented in terms of minimum detectable odds ratios to improve comparability between studies. Finally, we discuss other difficulties with retrospective community studies.

METHODS AND MATERIALS

Criteria for Inclusion

The literature on studies of lung cancer and other health effects in communities around copper smelters was reviewed. Employee studies were excluded (thus, only three[9–11] of six papers by Nordstrom and colleagues on the Ronnskar smelter were included). In cases where both occupationally and non-occupationally exposed people were studied, only the portions of the paper that dealt with community health effects were analysed. Two unpublished studies[15,17] were brought to our attention and included. Table 1 presents some descriptive information about the studies. The column labelled 'model' refers to our method of analysing the data and will be explained below.

Statistical Methods

Three quantities were calculated for each study reviewed—the observed result, the maximum reasonable risk (MR) given the data, and the minimum detectable risk (MDR) given the study design. The observed result is self-explanatory. We define maximum reasonable risk as the upper limit of a 95% one-sided confidence interval for the true risk. Therefore, the MR will generally have the form

$$r_{me} = \hat{r} + 1.645 * S_{\hat{r}} \qquad (1)$$

where $\hat{r}$ is the observed result (such as a log-odds ratio), 1.645 is the 95th percentile of the standard normal distribution, $S_{\hat{r}}$ is the standard error of $\hat{r}$, and $\hat{r}$

TABLE 1 *Description of studies reviewed. Model refers to the models described in the text. For the 2-sample model, N_1 is the average size of the exposed group over the period of the study; N_2 is the size of the unexposed group. For the regression model, N_1 is the total sample size*

Reference	Health effect	Model	Sample size N_1	Sample size N_2
Blot and Fraumeni[4]	Lung cancer (mortality)	2-sample	not given	US population
Milham[7]	Hearing tone	2-sample	566	17623
	Hearing loss	1-sample‡	6	
Rom et al[8]	Lung cancer (mortality)	regression†	2065	
Nordstrom[9]	Birthweight	2-sample t-test	1846	4542
Nordstrom[10]	Spont. abort.	regression*	4236	
Nordstrom[11]	Congen. malf.	regression*	24018	
	Cleft palate and/or lip	regression*	24018	
Lyon et al[12]	Lung cancer (incidence)	regression†	858	
Greaves[13]	Lung cancer (incidence)			
	Utah	2-sample	62	161
	Arizona	regression†	271	
	New Mexico	regression†	117	
	Idaho	regression†	52	
	Montana	2-sample	22	53
Polissar[14]	Lung cancer (incidence)	2-sample†	1910	11096
		2-sample†	1828	11096
		2-sample†	1828	559082
Hartley & Enterline[15]	Lung cancer (mortality)	regression*	148673	
Matanoski et al[18]	Lung cancer (mortality)			
	Males '58–'62	2-sample	35337	588098
	'68–'74	2-sample	42106	300328
	Females '58–'62	2-sample	36254	619444
	'68–'74	2-sample	43856	310679
Pershagen et al[16]	Lung cancer (mortality)	2-sample	13171	23393
Frost et al[17]	Lung cancer (mortality)	2-sample	124486	US female population

* general population used for control group
† another disease type used for control group
‡ H_0: $p_1 = 0.01$, H_a: $p_1 > 0.01$

is approximately normally distributed. The ME is based on the data and is an attempt to present a 'worst case' viewpoint.

In contrast, the minimum detectable risk (MDR) is not based on the observed data; instead, it may be computed knowing only the study design and some background information about the control population (ie for normally distributed variables the standard deviation of the effect must be known; for binomially distributed variables, the probability of disease mortality in the control population must be known). The MDR is the smallest difference between the health effect statistic and its null hypothesis value which has a specified probability (power) of being declared 'significant'. This depends on the sample size, variance, power and significance level.

For a normally distributed random variable, r (for example, the log-odds ratio for some health effect), the expression for minimum detectable risk is

$$r_{mdr} = r_o + (Z_{1-\alpha} + Z_{1-\beta}) * S_r \qquad (2)$$

where r_0 = null hypothesis value of r
$Z_{1-\alpha}$ = Normal deviate corresponding to an α-level test of the null hypothesis
$Z_{1-\beta}$ = Normal deviate corresponding to a power of $1-\beta$
S_1 = standard error of r.

Since S_r is a function of the sample size, the MDR depends on n also. When n is large (as is the case for most of the studies reviewed here) the assumption of normality is reasonable. For smaller sample sizes, more complicated procedures may be necessary to compute the MDR.

All of the studies investigate proportions or rates of occurrence (excepting the birthweight studies by Nordstrom[9]) of some health effect in populations with varying exposures. Most studies used one of two designs, described below. For simplicity, we have reanalysed the studies and report observed results, maximum risks and MDRs from our analyses. Usually, our reanalyses are less complex than the author's original analyses. For example, we pool data over groups (eg sex) whereas the original analysis may have stratified on the grouping factor (using a Mantel-Haenszel procedure, for instance). We found that in most cases pooling did not significantly change the results, while the power calculations are easier for the simple models. In the one case[18] where pooling did make a significant difference, we report results for each strata. In no case did these slight changes in analytical methods change the overall conclusions of the studies. Statistical methods are discussed in more detail below.

Design Types

The simplest design[6,7,13,14,16-18] involves the measurement of a health effect in an exposed population and a comparable control population. If p_1 represents the probability of disease in the N_1 exposed people, p_2 the probability of disease in the N_2 control people, $q_1 = 1-p_1$ and $q_2 = 1-p_2$ then the odds ratio, OR, is

$$OR = \frac{p_1 q_2}{p_2 q_1} \qquad (3)$$

Letting c = ln(OR), the log odds ratio, the null and alternative hypotheses of interest are

$$H_0: c = 0$$
$$H_a: c > 0$$

This model will be referred to as the 'two-sample' model, since two populations are compared. The formulas for MR and MDR for this model are given in the appendix.

The second type of design[8,10-13,15] considers the probability of disease as a function of distance from the smelter. Some tests for trends in proportions are described in references.[19-21] We used the logistic model

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = a + b/d \qquad (6)$$

where p is the probability of disease and d is distance (in miles) from the arsenic source, a surrogate for dose or exposure, and a and b are parameters to be estimated. The hypotheses are

$$H_0: b = 0$$
$$H_a: b > 0$$

This will be referred to as the 'regression' model. Two variants of the regression model were used. In references 10, 11, 15 the general population was used as the control group. In references 8, 12, 13 people with some type of disease (such as prostate cancer), which is presumed to be unrelated to arsenic exposure, were used as controls. In general, the investigators using regression methods did not specify whether 1/d or d (with appropriate change in H_0) was used as the index of exposure. However, we find the use of 1/d more satisfying since it implies a constant proportion (logit(p) = a) when one is sufficiently far from the arsenic source. Equations for MR and MDR in the regression model were given in the appendix.

Comparison of Studies

Since all but the birthweight study[9] deal with changes in proportions, it is possible to compute an odds ratio between the exposed group and the unexposed group. For the two-sample design, appendix equation 2 gives

the MDR expressed as an odds ratio. For the regression model appendix equation 4 gives the MDR as an odds ratio comparing incidence at one mile to background incidence. In the results section, then, the MR and MDR are always expressed in terms of odds ratios to facilitate comparison between studies.

RESULTS

Table 2 presents the observed results, maximum risk and MDR for each study based on our re-analysis. Observed odds ratios range from 0 to 10.59. MRs range from 0.4 to 432 and the MDRs range from 1.18 to 892. The observed results were almost evenly split between deleterious and protective effects of arsenic. Of the 24 observed results, 10 indicate a harmful effect and the other 14 suggest a protective effect or no association. Five of the observed results showed a statistically significant ($p < 0.05$) increase in morbidity and six showed a statistically significant decrease ($p > 0.95$).

Attempts to set an upper bound on the effects of arsenic using these studies would not be appropriate. First, four of the maximum reasonable risks (MR) implausibly suggest that arsenic improves health (odds ratio <1.0). Second, eight of the MRs were larger than 2.0; in four cases, the MR was larger than 10. Wide confidence bounds such as these are not very useful since it is unlikely that community exposure could result in such large increases in risk.

Most of the studies had little power to detect small risks. The MDR expressed as an odds ratio is greater than 2.0 in 13 of the 22 cases where it could be calculated and greater than 1.18 in all cases. For these studies there is little hope that subtle health effects would be detected even if they existed.

Since the studies are not powerful enough individually, we considered the possibility that several of the studies, taken together, might provide a more meaningful result. Lung cancer is the most studied health effect in Table 2, so we used two approaches to combine the results from the 18 lung cancer studies. The first approach is estimation-oriented. By assuming that the log odds ratio is normally distributed, one can combine the results of the various studies to get a

TABLE 2 *Observed results, maximum reasonable risk and minimum detectable risk for papers reviewed. Except for birthweight, all entries are odds ratios*

Reference	Health effect	Observed result	P	Maximum effect	MDR
Blot and Fraumeni[6]	Lung cancer (mortality)	1.16*	0.001	unable to compute	
Milham[7]	Hearing tone	0.235	0.99	0.424	2.44
	Hearing loss	0.000	0.99	19.8	50.0
Rom *et al*[8]	Lung cancer (mortality)	0.759	0.83	1.20	2.00
Nordstrom[9]	Birthweight	−68 g*	0.0001	−98 g	−30 g
Nordstrom[10]	Spont. abort.	2.07*	0.001	3.04	1.78
Nordstrom[11]	Congen. malf.	0.701	0.69	2.24	5.77
	Cleft palate and/or lip	0.027	0.90	2.45	892
Lyon *et al*[12]	Lung cancer (incidence)	10.6	0.15	432	273
Greaves[13]	Lung cancer (incidence)				
	Utah	1.43	0.14	2.47	2.28
	Arizona	0.311	0.95	1.03	6.11
	New Mexico	4.01	0.16	41.0	33.5
	Idaho	0.37	0.67	14.5	257
	Montana	0.28	0.99	0.70	4.02
Polissar[14]	Lung cancer (incidence)	1.06	0.26	1.23	1.26
		0.78	0.98	0.94	1.33
		0.77	0.99	0.92	1.31
Hartley & Enterline[15]	Lung cancer (mortality)	1.00	0.50	1.22	1.35
Matanoski *et al*[18]	Lung cancer (mortality)				
	Males '58–'62	1.24	0.13	1.70	1.61
	'68–'74	1.46*	0.003	1.85	1.41
	Females '58–'62	0.35	0.85	1.84	12.30
	'68–'74	0.88	0.63	1.64	2.54
Pershagen *et al*[16]	Lung cancer (mortality)	2.50*	0.0016	4.17	2.41
Frost *et al*[17]	Lung cancer (mortality)	0.97	0.67	1.08	1.18

* Result significant at the 0.05 level

pooled risk estimate. This was done both for mortality studies and incidence studies separately and for all lung cancer studies combined. The results are shown in Table 3. However, a comparison of the variability of the log odds ratios between studies to the pooled within-study variability shows considerable heterogeneity between the individual studies; therefore, interpretation of the pooled result is difficult.

A second, test-oriented, approach to pooling results from several studies is Fisher's method of combining p values.[22] The procedure is to compute

$$T_\ell = -2 \sum_{i=1}^{\ell} \ln(p_i)$$

for the ℓ tests and compare this to a $\chi^2_{2\ell}$ distribution. The result is $T_\ell = 61.3$ on 18 tests yielding an overall p-value of 0.006. However, in at least two of the 'significant' studies[6,16] the elevated effects are partly or wholly due to the inclusion of smelter workers in the samples. When these tests are excluded, $T_\ell = 34.6$ on 16 tests ($p > 0.25$). Additionally, three of the most powerful studies[14,15,17] show no evidence of a deleterious effect. The combined results, therefore, fail to provide much additional insight into the community effects of arsenic.

DISCUSSION

Even among the most powerful studies (MDR < 2.0) considered in this review, the results range from highly suggestive of a deleterious effect of arsenic ($p = 0.0001$)[9] to highly suggestive of a beneficial ($p = 0.99$)[14] effect. The remaining studies are almost evenly split between deleterious and beneficial effects. Pooling the studies does not provide any additional insight and, in fact, there is evidence of heterogeneity among studies which should be testing for the same effect. In the balance of this section we discuss some of the reasons that these numerous studies cannot be used to rule out anything more than improbably large health risks from community arsenic exposure.

None of the studies has sufficient power to detect the small changes in risk which may be associated with

TABLE 3 *Estimates of odds ratios for lung cancer by pooling results from studies shown in Table 2. (Note: reference 6 is not included in this table because a variance could not be computed from the published information)*

	Pooled OR	95% confidence interval
Mortality	1.14	(0.690, 1.88)
Incidence	1.02	(0.460, 2.28)
All	1.08	(0.660, 1.43)

chronic low level exposure to inorganic arsenic. As we will suggest shortly, the odds ratio for lung cancer due to exposure to arsenic in the community is unlikely to be as large as even the smallest MDR (1.18) in Table 2. Therefore, issues of statistical power are central to evaluating the results of community studies. However, few of the authors adequately consider the power of their studies and some do not provide enough information for readers to determine power on their own (ie ref. 6). Additionally, in some cases[8,12] it appears that the concept of power is misunderstood. In references 8 and 12 the authors use an inefficient test for trend[23] to relate the probability of disease, p_d, to distance, d, from the smelter. In attempting to increase power, the authors base their estimate of p_d on the entire population up to distance d (instead of using only the population at distance d—the standard design). Since the denominator in each p_d has been 'increased', this method is supposed to increase power. However, it is clear that no additional information has been gained, since one is just reusing the nearer populations at each distance. In fact, it can be shown that the design proposed by Lyon *et al*[23] actually yields a less powerful test than the standard design.

In addition to low statistical power there are several possible sources of bias and confounding in community health studies which do not appear to be adequately controlled for in the papers discussed herein. These include the effects of migration, uncontrolled confounding, and reporting bias. Each of these is discussed below.

The effects of migration are not considered in any of the studies except Frost.[17] People are classified as exposed or unexposed according to where they lived during the study period, regardless of length of residence. However, for cancer there is a latent period of decades between initial exposure and clinical disease. In- and out- migration occurs throughout this period, resulting in a decrease in the measured excess risk. Polissar[24] gives some estimates of the effect of migration on relative risk calculations for cancer. For example, suppose lung cancer rates are compared between exposed and unexposed areas. Due to migration the excess risk will, on the average, be reduced below the true risk by 20–60% for latent periods varying from 10 to 40 years, respectively. If areas smaller than towns are being compared, such as census tracts or small concentric rings around a smelter, migration across their boundaries will be greater and the decrease in excess risk will be even larger.

Several other types of confounding may have occurred in these studies. Confounding variables could cause the observed risk to be either higher or lower

than the true risk. Smoking was not always controlled for, and socioeconomic status was generally assumed to be the same in both the exposed and unexposed population (socioeconomic status was usually the major consideration in choosing the control population). Occasionally exposed people were not removed from the study populations in some cases.[6,16] Reporting bias may be present if physicians near a smelter are more likely to diagnose a particular condition (due to familiarity with the condition in factory workers) than physicians further away. Finally, there are confounders which would tend to decrease the apparent risk. These include selective out-migration (if diseased people moved away from areas near a smelter) or improper controls (Lyon *et al*[12] used lymphomas as the control cancer yet Ott[25] found that lymphomas are also associated with arsenic exposure).

We have discussed some of the types of bias, power problems and statistical faults which are apt to affect studies of community health. Ultimately, however, there is some question of whether the risks around a smelter (or many other pollution sources) are large enough to measure. For example, suppose the relative risk for lung cancer is as high as 5.0 among a group of workers highly exposed to fumes and dust in the confines of a smelter building (the best evidence[1] indicates that the risk is probably lower). It is likely that these effluents are highly diluted in the open spaces of a neighbouring community—perhaps by factors from a hundred to a million. If the excess risk of 4.0 is reduced by a similar proportion, then we are trying to detect a relative risk of 1.04 to 1.000004, respectively. Enormous sample sizes would be needed to detect such a relative risk. It would be difficult if not impossible to control confounding factors to the extent that such a subtle risk would be detected. Stated differently, would a statistically significant relative risk of 1.04 be believable, given the imprecise nature of epidemiological information?

In summary, it may be impossible to find the powerful combination of sufficiently large risks combined with sufficiently large exposed populations. However, this does not mean that the probable low risks are unimportant. A potential risk of 1.04 or less may still be of concern because those at risk are involuntarily exposed and because of the anxiety that it may produce in a community. Additionally, the Environmental Protection Agency has established a policy for carcinogens such that the additional lifetime risk from exposure be less than 10^{-6}. It is likely, however, that estimates of such risks will have to be made without relying on direct observation. Instead, extrapolation from occupationally exposed groups and/or modelling, with its attendant limitations and assumptions, must be used.

Finally, we must emphasize that, despite their limitations, studies of the type we have reviewed are valuable. In the specific case of arsenic, an example of a human carcinogen which has not been shown to be carcinogenic in animals, it is impossible to extrapolate from animal models. In addition, these epidemiological studies are generally inexpensive (of the order of $10,000 as compared to $1,000,000 or more for a standard rodent bioassay) and may detect an unexpectedly high risk. As a minimum, however, investigators planning such studies should calculate the minimum detectable risk to determine if it is worth proceeding. At the conclusion of a study, the methodology, including power, should be described thoroughly, limitations should be discussed and confidence intervals should be presented for each risk estimate.

APPENDIX

I. *Formula for MR and MDR odds ratios—two-sample model*

If $\hat{O}$ is the observed odds ratio or relative risk, then the MR is

$$MR = (\hat{O})\exp(1.645*S) \qquad (1)$$

where

$S = \sqrt{\frac{1}{n_1p_1} + \frac{1}{n_1q_1} + \frac{1}{n_2p_2} + \frac{1}{n_2q_2}}$ is the standard deviation of $\hat{O}$. The MDR ($\alpha = 0.05$, one-sided and $\beta = 0.2$) is

$$MDR = \exp((1.645+0.84)*S). \qquad (2)$$

If $\hat{O}$ is reported as the standardized mortality ratio, a simpler method to use is

$$S = \sqrt{(\ln \hat{O})^2/\chi^2}$$

Where χ^2 is the Mantel–Haenszel statistic.

II. *Formula for MR and MDR odds ratios—regression model*

If $\hat{b}$ is the observed regression coefficient, then the ME is

$$MR = \exp(\hat{b}+1.645*S_b) \qquad (3)$$

where S_b is the usual standard deviation of the regression coefficient. The MDR ($\alpha = 0.05$, one-sided and $\beta = 0.2$) is

$$MDR = \exp((1.645-0.84)*S_b). \qquad (4)$$

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REFERENCES

[1] Enterline P E, Marsh G M. Cancer among workers exposed to arsenic and other substances in a copper smelter. *Am J Epidemiol* 1982; **116:** 895–911.

[2] Lee A M, Fraumeni J F. Arsenic and respiratory cancer in man: An occupational study. *JNCI* 1969; **42:** 1045–52.

[3] Pinto S S, Bennett B M. Effect of arsenic trioxide exposure on mortality. *Arch Environ Health* 1963; **7:** 583–91.

[4] Kuratsune M, Tokudome S, Shirakusa T, Yoshida M, Tokumitsu Y, Hayano T, Seita M. Occupational lung cancer among copper smelters. *Int J Cancer* 1974; **13:** 552–8.

[5] Axelson O, Dahlgren E, Jansson C D, Rhnlund S O. Arsenic exposure and mortality: A case-referent study from a Swedish copper smelter. *Br J Industr Med* 1978; **35:** 8–15.

[6] Blot W J, Fraumeni J F. Arsenical air pollution and lung cancer. *Lancet* 1975; July 26: 142–5.

[7] Milham S. Studies of morbidity near a copper smelter. *Environ Health Perspec* 1977; **19:** 131–2.

[8] Rom W N, Gloria V, Lyon J L, Shopkow S. Lung cancer mortality among residents living near the El Paso smelter. *Br J Industr Med* 1982; **39:** 269–72.

[9] Nordstrom S, Beckman L, Nordenson I. Occupational and environmental risks in and around a smelter in northern Sweden I. Variations in birth weight. *Hereditas* 1978; **88:** 43–6.

[10] Nordstrom S, Beckman L, Nordenson I. Occupational and environmental risks in and around a smelter in northern Sweden. III Frequencies of spontaneous abortion. *Hereditas* 1978; **88:** 51–4.

[11] Nordstrom S, Beckman L, Nordenson I. Occupational and environmental risks in and around a smelter in northern Sweden. VI Congenital malformations. *Hereditas* 1979; **90:** 297–302.

[12] Lyon J L, Fillmore J L, Klauber M R. Arsenical air pollution and lung cancer. *Lancet* 1977; Oct. 22: 869.

[13] Greaves W W, Rom W N, Lyon J L, Varley G, Wright D D, Chiu G. Relationship between lung cancer and distance of residence from nonferrous smelter stack effluent. *Am J Industr Med* 1981; **2:** 15–23.

[14] Polissar L. Cancer incidence in relation to a smelter. University of Washington Department of Biostatistics Technical Report #28 1978.

[15] Hartley J, Enterline P. Lung cancer mortality in a community surrounding a copper smelter. Unpublished manuscript 1981.

[16] Pershagen G, Elinder C, Bolander A. Mortality in a region surrounding an arsenic emitting plant. *Environ Health Perspec* 1977; **19:** 133–7.

[17] Frost F, Milham S, Harter L, Bayle C. Tacoma-Area Lung Cancer Study. Unpublished Manuscript 1984.

[18] Matanoski G, Landu E, Tonascia J. Cancer mortality in an industrial area of Baltimore. *Environ Res* 1981; **25:** 8–28.

[19] Mantel N. Chi-square tests with one degree of freedom: extensions of the Mantel-Haenszel procedure. *J Am Stat Assoc* 1963; **58:** 690–700.

[20] Armitage P. Tests for linear trends in proportions and frequencies. *Biometrics* 1955; **11:** 375–85.

[21] Chapman D, Nam J. Asymptotic power of chi-square tests for linear trends in proportions. *Biometrics* 1968; **24:** 315–27.

[22] Kozial J, Perlman M. Combining independent chi-squared tests. *J Am Stat Assoc* 1978; **73:** 753–63.

[23] Lyon J, Klauber M, Graff W, Chiu G. Cancer clustering around point sources of pollution: assessment by a case-control methodology. *Environ Res* 1981; **25:** 29–34.

[24] Polissar L. The effect of migration on comparison of disease rate in geographic studies in the United States. *Am J Epidemiol* 1980; **111:** 175–82.

[25] Ott M, Holder B, Gordon H. Respiratory cancer and occupational exposure to arsenicals. *Arch Environ Health* 1974; **29:** 250–5.

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